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Facilitating the Growth of Local Energy Communities

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Document Version
Publisher's PDF, also known as Version of record

Publication date:
2017

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):
Timmerman, W. H. (2017). Facilitating the Growth of Local Energy Communities. [Groningen]: University of Groningen, SOM research school.

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Download date: 12-11-2019

Facilitating the Growth of Local Energy Communities

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Published by: University of Groningen
Groningen
The Netherlands

Printed by: Ipskamp Printing

ISBN: 978-90-367-9708-5 (printed version)
978-90-367-9707-8 (electronic version)

Willem Hendrik Timmerman
Facilitating the Growth of Local Energy Communities
Doctoral Dissertation, University of Groningen, The Netherlands

Keywords: decision enhancement, decision making, local energy, communities, prosumer communities, design science

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Facilitating the Growth of Local Energy Communities

Proefschrift

ter verkrijging van de graad van doctor aan de
Rijksuniversiteit Groningen
op gezag van de
rector magnificus prof. dr. E. Sterken
en volgens besluit van het College voor Promoties.

De openbare verdediging zal plaatsvinden op
donderdag 11 mei 2017 om 16:15 uur

door

Willem Hendrik Timmerman

geboren op 16 juni 1962
te Ruinerwold

Promotores

Prof. dr. G.B. Huitema
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“If we want things to stay as they are .... things will have to change.”
Giuseppe Tomasi di Lampedusa, The Leopard

To ´Pa en Moe´

Preface and acknowledgements

It was after the summer holidays that I sat at the table with Wim van Gemert and Marcel Koenis, who then just started the Energy Expertise Centre at the Hanze University. Wim was making jokes, as always, but this time also some more serious things were tabled. He challenged me to start a PhD research at the Energy Expertise Centre. “You are research minded, and with your ICT background there are some big challenges awaiting for you to tackle,” were more or less his words. For me this had to sink in first. But the thoughts would not abandon me. Sustainability was a subject that fascinated me, while the developments in the field of sustainable energy were very interesting! It would be a unique opportunity to create my own field of research and delve deep into the world of local energy communities. There was something going on out there, and things were going to change. And here was a chance to possibly contribute to this change. I decided to go for it!

This research focuses on the emergence of local energy communities, where citizens take up the challenge to organise the sustainable energy provision in their own region themselves. But many of these initiatives struggle with the complexities of the energy world, and they are faced with complex decisions when they have to solve problems that hinder their further development. Complexities are related to renewable energy technologies, their infrastructural embedding, financial viability, public acceptance, and diverse commercial and political interests.

This thesis describes a solution - a shopping mall in the form of an online portal - that facilitates the decision enhancement of local energy communities. The shopping mall offers facilities to guide the communities in finding information, and choosing the right tools and services they need from the various shops in the mall. This way the local energy communities are relieved and supported in making decisions.

Now, I am looking back on a fascinating and very valuable period of my life. Yes, it was a dive into the deep. And yes, sometimes it was hard to make clear what I was working on. There were moments of doubts when it crossed my mind to throw in the towel. So far, nothing new while this was predicted when I started. But after all, I was happy that I left the towel in the corner. That I did step in the ring for the next round. It made me stronger to persist because the enthusiasm and drive of the people behind the local energy communities gave

me so much energy. It was contagious. My work would have been impossible without the cooperation of the various communities in both the exploration and the evaluation phase of my research. I therefore want to thank all the participants for their contributions and their shared energy.

When I render thanks, I want to mention two persons in particular, who were my beacons and leadsmen in this process: George Huitema and Henk Sol. As my promotores, you inspired me, gave me directions with your extensive expertise, sometimes confronted me, with once in a while tough discussions. But above all, I really admire your patience and perseverance, which I did put to test more than once. Many, many thanks for all the time and effort that you invested in me. I hope you accept my gratitude as a contribution to your return on investment.
Furthermore, I would like to thank the Hanze University for giving me the opportunity for doing this PhD research. The knowledge and experience that I gained already proved to be very valuable while I could integrate it in my teaching. The support of my colleagues from the Human Technology and Industrial Product Design team was very valuable for me, and I hope they were not bothered too much with my 'other work'. Once in a while, my colleagues of the Energy Expertise Centre acted as sparring partners when I ran into some questions, or they reviewed part of my work, and I could try out my presentations. I had great pleasure in working in the Flexines project, with both people from the Hanze and TNO. We did some pretty cool things in that project! The regular meetings with my colleague PhD candidates, together with the lectors Wim van Gemert and Jan Peter Nap, were of great value, while we could share the good and the bad experiences, the laughs and the tears, which helped to learn from each other. And Ko, thanks for giving your valuable 'layman' feedback.

I should not forget the work of the students that contributed to my research: Pieter Faber, Pieter Glas, Niels Luten, Rutger Kamps, Jeroen Noordman and Bram Visser. Although your work possibly is not directly visible in my thesis, indirectly you all contributed to my way of thinking. One student I want to mention in particular: Henk Bolhuis. His contribution is very clearly visible: he built the shopping mall prototype, which was an indispensable tool in the last phase of my research. Henk, you did a great job!

Who I am, and where I am now would never have been possible without the dedication of my parents. What they did for me and my six sisters and brothers is hard to describe. When I was younger I was not always conscious of their hard work and the great sacrifices they made, in order to give us the opportunity to get the most out of our talents. Not pushing, always

stimulating. When I grew older, I started to realise that this was not self-evident at all. I did my best to show them my gratitude, many times, but it can never ever be enough for what they did. And I am very sorry that they cannot be my witness. My deepest love and respect!

Diet, my dearest. Which words to use to you? All these years you stimulated and supported me, sometimes you effaced yourself, you listened, you fell asleep. But above all, you were and are my best mate! I promise you one thing: you never have to bike alone again!

Wim Timmerman, Groningen, March 2017

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1 Introduction

In this chapter we explain the emergence of local energy communities and their potential role in the transition to a sustainable energy system. Insight in their growth path is still lacking, as well as means to facilitate them in their growth from initial idea and first initiative towards a full-grown local energy community. Here we present the problem statement, the objective and research question together with the research approach we will follow.

1.1 Transition to a sustainable energy system

The threats of climate change sparked the sense of urgency to radically change the way how we live and how we use our planet's natural resources. Back in the seventies, the Club of Rome predicted in their book 'The Limits to Growth' (Meadows et al., 1972) that the consequences of worldwide exponential economic and population growth could lead to the depletion of the earth's natural resources. Fifteen years later, the Brundtland Report 'Our Common Future' (Brundtland, 1987), commissioned by the United Nations, presented a political agenda for a worldwide sustainable growth path that should prevent the doom scenarios that were presented by the Club of Rome. In the late nineties, the Kyoto protocol was established (Breidenich et al., 1998) in which the industrialised nations legally committed themselves to reduce their greenhouse gas emissions. At the end of 2015, 195 countries agreed on the so-called Paris Agreement of the United Nations Framework Convention on Climate Change to set targets for emission reductions and to do their best to keep global warming well below 2 degrees Celsius (UNFCCC, 2015).

One crucial element in the transition towards a climate neutral society is the switch to renewable energy sources[1] The Netherlands Environmental Assessment Agency (PBL) and Energy research Centre of the Netherlands (ECN) (Ros et al., 2011) worked out a number of scenarios how the Netherlands could reach their climate goals that were set for 2050 (Rijksoverheid, 2011), that also connects to the European Union Roadmap 2050 (Roadmap, 2011). Large investments are needed to make the energy network future proof, including the large scale integration of renewable sources (Damsté et al., 2011; Mulder et al., 2012). Damsté et al. (ibid) state

[1] Renewable energy means generating useable energy in the form of electricity or heat, while the resource base is not depleted or significantly diminished (Walker & Cass, 2007).

that at the local level, a lot of effort will have to be put into making networks more intelligent, so that an optimal match between supply and demand can be achieved, including options for local storage of electricity. According to Netten (2011) smart grids, including the introduction of smart meters, form a stepping stone for the realization of a platform for new services and products. This could lead to a major shift in the energy value chain, because the energy market will become more service oriented instead of product driven, where energy is considered a commodity product. Service orientation opens up the market for new players with new business models, while the role of the end-user[2] from currently being a passive consumer will change to a more active one.

1.2 Energy communities: energy transition at a local level

The changing role of the end-user

In the Netherlands the energy consumption of households covers well over 25% of the total Dutch energy consumption (Gerdes et al., 2014). When households, as end-users, can be stimulated to reduce their energy consumption and/or switch to the use of renewable energy sources, they can significantly contribute to the realisation of a more sustainable[3] energy system. Watson et al. (2008) state that domestic micro-generation[4], with electricity and heat generation in individual homes, could contribute as much as 40% to the UK electricity demand by 2050. According to Steg (2008) the first step that has to be taken to involve end-users in the energy transition process, is to create awareness. Only when awareness is established, the actual energy behavioural change of households can be realised. Steg (ibid) indicates that three barriers need to be addressed, in order to influence energy behaviour: 1) the current insufficient knowledge of effective ways of how to reduce households' energy, 2) the low priority that is given to, and the presumed high costs of energy savings, and 3) the lack of knowledge of what are feasible alternatives. Education of end-users is therefore a point of particular interest. Midden et al. (2007) describe that technology and behaviour are closely related, when an integrated approach is being pursued to promote energy conservation. They state that well designed technical environments, systems, and products have a great potential for supporting environmentally sustainable behaviour. Verbong et al. (2012) note in their

[2] The term end–user refers to both individual consumers and business users.

[3] Definition of sustainability of the Brundtland commission in Our Common Future (Brundtland, 1987): "Sustainable development is the kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

[4] Micro-generation is defined as the small-scale production of heat and/or electricity from a low carbon source (Allen et al., 2008).

study of smart grid experiments in the Netherlands that users have not been actively involved in grid innovations, although very likely they will play a pivotal role in the future of smart grids. They conclude that "we should start with developing value added services that the energy system could deliver, instead of first focusing on the technological options to improve the system." They advocate a more serious role for users (e.g. households or communities) in the energy transition process.

The Dutch Taskforce Intelligent Grids (Netten, 2010) formulated a vision on the changing role of the end-user from being 1) a passive energy consumer, to 2) a more active one, choosing his own supplier and partly generating his own energy, towards eventually 3) a participative consumer, who generates his own energy, picks and chooses value added energy services that fit to his needs, and who trades energy with dynamic, value-based pricing. The passive consumer thus becomes *a participative prosumer*[5]. The European Technology Platform for the Electricity Networks of the Future (SmartGrids, 2012) defines prosumers as "consumers with the additional role of self-provided (owned) electricity generation and/or storage for private, daily life needs, comfort and small and medium enterprises' (SME) business needs."

Organising sustainable energy at a local level

Next to the changing role of the end-user in the energy system, there is another noteworthy development that characterises the changing energy playing field. Recent years have shown the emergence of numerous energy initiatives, where groups of citizens organize themselves with the aim to establish their own sustainable energy provision at a local level (AgentschapNL, 2010; Haar et al., 2011). This way they form a local energy community. Walker & Cass (2007) characterise local energy community initiatives as having involved processes of project development that are to some degree local and collective in nature, and/or having beneficial project outcomes (economic and social) that are also, to some degree, local and collective, rather than distant, individualised or corporate in destination. Hielscher et al. (2013) identified four specific characteristics of energy community initiatives. First, they are multi-faceted, as they often combine various activities within their initiatives such as stimulating energy savings, organising collective purchase of solar panels and organising sustainable energy supply. Second, they change contexts while they operate in changing environments where they attract attention of policy makers. In the third place, engagement is included through the active participation of citizens. And

[5] The term prosumer was first introduced by futurist Alvin Toffler in his book The Third Wave (Toffler et al., 1981). See also 'The coming of age of the prosumer' by Ritzer et al. (2012).

lastly, values are put into practice by influencing the energy consumption behaviour of participants.

In the last decade there is an increase of the number of local energy communities in the Netherlands, mostly bottom-up movements started by citizens, which was preceded by the emergence of wind cooperatives some twenty to twenty five years ago. A majority of initiatives has chosen for the legal organisational form of a cooperative[6]. The initiatives can be subdivided into a number of sub-categories (Schwencke et al., 2013):

1. Wind cooperatives, with a history that dates back to the 1980's.
2. Local energy cooperatives or enterprises.
3. Project cooperatives that are established for one specific project or production installation (i.e. wind mill, solar field). In some cases these project cooperatives are founded by local energy cooperatives.
4. Other forms of cooperation, such as crowdfunding collectives, cooperatives with municipalities or companies, cooperatives of energy suppliers, or cooperatives of cooperatives ('umbrella' cooperatives).

At the end of 2016 there were in total 256 local energy cooperatives, 19 wind energy cooperatives and 57 project cooperatives active in the Netherlands (Schwencke, 2016). 75% of the energy cooperatives are established after January 2013. In total, these cooperatives represent at least 50.000 members (exact numbers were not available from all initiatives). 23 MWp has been realised with the installation of 90.000 collective solar panels, representing an investment of 30 to 35 Million Euros. Another 36 MWp of collective solar projects is being planned for 2017 and another 46 MWp is in preparation for realisation after 2017. Since the start of the first Dutch wind cooperative in 1986 115 MW of cooperative wind power has been realised, and another 87 MW is being planned for the near future. These figures indicate that the collective and cooperative energy initiatives represent a potentially serious component of the energy system (Schwencke, 2016). Furthermore, there are a number of initiatives that realised or investigate collective heat and hydropower projects. Though the initiatives vary in context, size and ambitions, the main common factor is their focus on energy savings, local generation and supply of sustainable energy, and reinforcing local/regional economic activities.

Depending on local circumstances, various sustainable resources are being applied such as solar energy, wind mills, biomass, thermal heat or hydropower. Besides energy, some community initiatives have a broader

[6] Other legal forms include, amongst others, association, foundation and Ltd.

focus, like for instance food and agriculture (e.g. local community vegetable gardens, food banks for socially deprived), care (e.g. small scale care for elderly people, voluntary care), tool sharing (e.g. peerby.com), communal fibre networks, or mobility (e.g. shared cars). Various motives underlie these initiatives like the demand to maintain the level of communal facilities, dissatisfaction with existing arrangements, or ideological motives (Houwelingen et al., 2014). Sometimes multiple activities are combined within one initiative. As an example, the revenues of a cooperative windmill project are invested in local social activities (e.g. the local library or the public swimming pool) that otherwise would have to close due to uneconomical conditions.

The role of Dutch authorities

The Dutch national government has set goals for reaching a large(r) part of sustainable energy in the total energy system. In 2020 14% of the energy should be provided from renewable sources, up to 16% in 2023. In 2023 offshore windmills should provide electricity for 5 million Dutch households. Eleven areas have been allocated for large onshore wind mill parks, where the 12 provinces have been delegated to set the task of realising 6.000 MW of generation capacity in these areas.

The national government and provinces are responsible for the development of sufficient regulations for local sustainable energy development, next to arranging the energy market organisation. The local authorities of Dutch municipalities also play a role in realising sustainability goals. On the one hand they act as upholder of local legislation and regulations, which apply to local energy communities. On the other hand they act as catalyst for instance by offering space for sustainability projects (e.g. roof tops of public buildings), providing subsidies, or playing the role of initiator or partner of sustainability projects themselves. A number of municipalities joined forces at a regional level and established an energy cooperative or local energy company. Although we do not include these cooperatives in this study, they often do cooperate with citizen initiated energy cooperatives (Schwencke, 2016).

In September 2013, the ‘SER Energieakkoord’ (Energy Agreement) was signed by more than forty Dutch organisations, representing a broad variety of stakeholders, where they endorsed their commitment to contribute to a faster implementation of a sustainable society and economy (SER, 2013). Goals were formulated and agreements were incorporated on both energy savings and on more sustainable energy generation. In the agreement the local energy communities are recognised as having an important role to

engage citizens to play an active role in the energy transition process ('energetic civil collectives').

Changes in society

The emergence of local energy communities is part of a broader societal development. On the one hand there is the trend of the retreating authorities, and at the same time we see new concerted actions of enterprising citizens, businesses and authorities (Straathof et al., 2012). In September 2013 the Dutch government acclaimed, in the yearly King's speech to the parliament, *the participation society* and *the do-democracy*, where they wanted to appeal to the individual responsibility of every civilian for their own and collective well-being in society (Dutch Government, 2013). Elzenga & Schwencke (2014) characterise this development as *the energetic society*, where the national authority decentralises tasks to lower authorities, to the market and to society. The United Nations acclaimed 2012 as the Year of the Cooperatives (UN, n.d.) with the motto 'Cooperative enterprises build a better world'. According to the International Co-operative Alliance the cooperative movement follows seven basic principles (ICA, n.d.): 1) it is voluntary and has open membership, 2) it is democratically controlled by the members, 3) membership participation has economic value, 4) it is autonomous and independent, 5) education and information dissemination are essential, 6) there is mutual cooperation between cooperatives, and 7) care for the community.

We note that cooperatives are of all ages. For example, traditionally, the Netherlands has a long history of cooperative organisations (Van Oorschot et al., 2013), where the first Dutch cooperative organisation, a farmers' association, was founded in 1837 (Parker & Cowan, 1944, p. 88). According to Van Oorschot et al. (ibid) the Netherlands has one of the largest non-profit sectors in the world, based upon pillarization, meaning the religious and/or political segregation of society, which is characterised by self-help, civil association, collective and individual input and gain. After Second World War de-pillarization has taken place in the Netherlands, although still ranked as the second most cooperative country in Europe (ibid).

Local energy communities: a definition

A wide variety of descriptions is being used to denote the phenomenon of local energy communities, like: energy initiatives, local sustainable energy companies, community sustainable initiatives (Forrest & Wiek, 2014), low carbon communities (Charnock & Alexander, 2007), urban level energy initiatives (Rydin et al., 2013). From now on in this thesis we will use the term *prosumer community*, because it nicely represents the dynamic characteristics

of the phenomenon of active citizens, who want to realise sustainability goals in their local community by producing and consuming their self-generated sustainable energy. We define the term *prosumer community* as follows:

> *"A prosumer community is a local, collective initiative, initiated by a group of citizens and organised in a legal entity, with the aim to establish on a non-profit bases local, self-supportive energy provision for their members, which is generated by both individually and collectively owned local facilities using renewable resources."*

There is a growing body of literature that describes the various aspects of energy transition and the role of decentralised energy generation. The subject of prosumer communities is described within various academic disciplines from various perspectives, such as what is their contribution to the energy transition process (e.g. Allen et al., 2008; Verbong & Geels, 2010; Watson et al., 2008), or the degree of citizen participation (e.g. Frieling et al., 2014; Lindenberg & Foss, 2011; Sauter & Watson, 2007; Steg, 2008; Watson, 2004), the role of communities in the process of decentralised generation (e.g. Walker & Cass, 2007; Warren & McFadyen, 2010; Watson, 2004), and the related policies and institutional frameworks (e.g. Egyedi et al., 2012; Loorbach & Rotmans, 2010; Pront-vanBommel, 2012). The development of the technical components of the future energy system and its impacts is also widely researched and described (e.g. Grijalva & Tariq, 2011; Kok, 2013; Pagani & Aiello, 2011; Passey et al., 2011).

1.3 Challenges facing prosumer communities

Although the emergence of prosumer communities is considered to be a rather new phenomenon (Watson et al., 2006), prosumer communities are seen as an important link in the transition towards a more decentralised energy system (Bomberg & McEwen, 2012; Walker & Cass, 2007; Warren & McFadyen, 2010). Specifically, because these community initiatives have the ability to engage and empower local people in a way that top-down efforts often fail (Forrest & Wiek, 2014). The transition path from the traditionally central-oriented energy system, towards a bottom-up local-scale energy provision with a local coordination scheme, can be regarded as an innovation process, which is basically dynamic and non-linear, consisting of various iterative phases (Allen et al., 2008). This dynamic and non-linear nature also applies to the development process or growth path of prosumer communities, where ambitious goals are being formulated to realise energy provision through local sustainable generation resources with and for the local community. Transition processes are radical in nature, because they aim to

change a current regime. These processes are sometimes revolutionary but mostly evolutionary, where the process itself typically follows a stepwise approach (Verbong & Geels, 2010). According to Walker et al. (2007) along this pathway "there are many complexities involved, choices available and strategic decisions needed in conceiving how such a shift and transformation can and should be achieved." Complexities and choices are related to, amongst others, the availability of multiple renewable technologies, their scale and infrastructural embedding, commercial viability, environmental impact, public acceptance, and to dealing with commercial and political interests. Walker (2008) also notes that community energy projects face various barriers, which may hamper their development. The experienced barriers include the legal conditions under which organisations or projects can operate, and their economic and technical viability. Furthermore, projects are confronted with "high risks and long return periods to recoup the upfront investments." Huijben & Verbong (2013) show that the Dutch energy regulations changed regularly over the last decade, where they conclude that inconsistent energy policies do not stimulate the development of for instance local collective energy projects. Walker (2008) argues that it is essential to involve expert advice and support, and to learn from previous experiences. His conclusion corresponds with the notion of Rotmans & Horsten (2012) that for the success of prosumer communities a combination of entrepreneurship and energy technology knowledge is essential, which is considered a rare combination. Therefore, Rotmans & Horsten argue, prosumer communities need to be facilitated in this while they also observe that this facilitation is mostly lacking. Hielscher et al. (2013) indicate growth as a big challenge for local energy communities as they often remain small scale because institutional support as well as viable business models are lacking.

According to Forrest & Wiek (2014) "numerous studies from various disciplines provide wide ranging insights into community sustainability initiatives, while they generally produce little practical knowledge that might provide guidance to practitioners and directly advance the effectiveness of initiatives." Forrest & Wiek (ibid) also note that "many more studies are needed to build an empirical knowledge base." Seyfang & Smith (2007) argue the need for "in-depth qualitative analysis to understand conditions for the germination of innovative processes at the grassroots, and the conditions for successful diffusion, examining the role of social networks and movements, scaling up, reproduction and market economy settings."

1.4 Problem statement

As we have seen in the previous section, one of the major issues that prosumer communities are facing is the lack of right expertise and knowledge for making decisions, while they are confronted with problems and complexities in the energy sector. This hampers their development process as they want to move forward towards realising their ambitious goals.

The notion of decision enhancement goes back to the 1960s, when the first computerised data-driven Decision Support Systems (DSS) were developed, followed by the development of the first Management Information Systems (MIS). Later on in the early and mid-1980s financial planning systems, spreadsheet-based DSS and Group DSS were implemented (Power, 2007). In the 1990s the concept of 'environments for supporting decision processes' was introduced, later on followed by the concept of 'studios for decision enhancement' (Keen & Sol, 2008). The studio-based approach is an extension to the decision support systems field, focusing on ill-structured and complex decisions that are termed as 'decisions that matter'. These decisions are characterised by being urgent, consequential, non-avoidable, non-reversible, unpredictable and wicked. A studio is often implemented as a facilitative interactive environment, providing decision enhancement services (DES) that aim to make a contribution to increasing decision process agility, addressing speed, flexibility, coordination, collaboration and innovation (Keen & Sol, 2008). It brings together *the people* that make the decisions, *the process* that influences the likelihood of making effective decisions, and *the technology* that provides multiple types and levels of support to both the people and the process. Decision enhancement theory and the studio concept have been applied in multiple studies and dissertations in the past decade, covering a wide variety of application domains, such as logistics brokering (Muniafu, 2007), disaster handling (González, 2010), miners start-ups (Basaza, 2012), sourcing public agencies (Knol, 2013), and water asset management (Katumba, 2015).

Thus, in this research we will focus on how prosumer communities can be facilitated in enhancing their decision making when confronted with various problems and complexities. This along their growth path from incubation towards realising self-supportive energy provision for the local community. Before we can define and realise this facilitation, we first need to get insight in the growth path of prosumer communities and which growth phases they go through. Furthermore, we need to know which decisions are involved along this growth path, and what is needed for making these decisions.

1.5 Objective and research question

From above we state that the objective of this thesis is to develop a decision enhancement environment that facilitates prosumer communities in order to enhance their decision making. The underlying proposition is that such an environment supports the growth path of prosumer communities and by that stimulates and accelerates the development process of prosumer communities from having an idea and a shared goal towards establishing a local sustainable energy community.

This leads to the main research question that we want to answer in this thesis:

RQ: How can prosumer communities be facilitated in enhancing their decisions along their growth path?

This main research question will be addressed by first answering three sub questions:

SQ1: How does the growth path of prosumer communities look like?

SQ2: What are the requirements of prosumer communities for decision enhancement along their growth path?

SQ3: How does a solution look like that meets the requirements?

1.6 Research approach

Galliers (1992) defines a research approach as a way of going about one's research, which may embody a particular style and may employ different methods or techniques. He further states that by considering the object of the research it is possible to use it to identify those approaches most likely to be appropriate for one's study. Orlikowski et al. (1991) state that a research approach is not rooted in a single overarching theoretical perspective, but exhibits a set of philosophical assumptions, regarding the underlying nature of the phenomenon being investigated, of the appropriate research methods to be used, and the nature of valid evidence. We present the research approach that is used to answer the research questions in three different dimensions: research philosophy, research strategy, and research instruments.

Research philosophy

According to Trochim et al. (2001) research philosophy refers to the perspectives that researchers possess in the process of knowledge

development. This entails the underlying assumptions about what constitutes valid research methods. When undertaking research of any nature, it is important to consider different research paradigms and matters of ontology and epistemology. Flowers (2009) defines a research philosophy as the perceptions, beliefs, assumptions, the nature of reality and truth (knowledge of that reality), that influences the way in which the research is undertaken, from design all the way through to the conclusions. According to Saunders et al. (2011) it is important to understand and discuss these aspects, in order to establish that approaches are congruent to the nature of the research, and aims of the particular inquiry are adopted, and to ensure that the researcher's biases are understood, exposed, and minimized.

Design science is the research philosophy that was chosen for this study. According to Ramesh et al. (2005) Design Science in Information Systems (DSIS) focuses on problem solving through system development, design of human-computer interfaces and architectural designs for computing and communication. Researchers seek to understand the real-life phenomena, identify practical problems and related requirements, and design explicitly applicable solutions introducing appropriate artefacts that can serve human purposes (Hevner & Chatterjee, 2010; Peffers et al., 2007; Vaishnavi & Kuechler Jr, 2007). The object of study in design science research is an artefact in context, and its two major activities are designing and investigating this artefact in context (Wieringa, 2014). Design science focuses on solving problems, where behavioural science theories are combined with the application of information technology, resulting in justified theory (truth) and artefacts that are effective (utility).

Hevner (2007) presents three interdependent cycles in design science research, as shown in Figure 1. The *relevance cycle* takes requirements from the contextual environment as input for the research, where the output of the research (the artefacts) is field tested in that environment. The *rigour cycle* provides the grounding theories and methods, along with domain experience and expertise from the foundations knowledge base, which are being used in the design cycle. New knowledge and expertise from the research are added to the growing knowledge base. The *design cycle* represents the research activities for the construction and evaluation of the designed artefacts and processes. The artefacts and processes are field tested in the relevance cycle, and need to be evaluated thoroughly before they can be uploaded as meta-artefacts into the knowledge base.

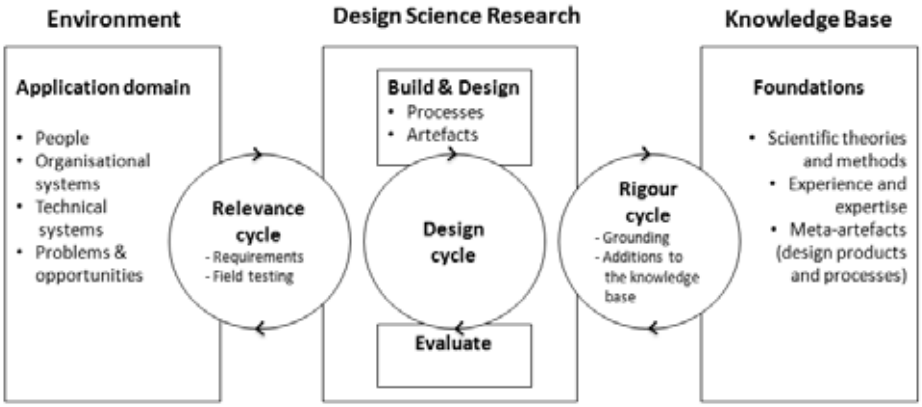


Figure 1: The three cycle view of Design Science Research (Hevner, 2007)

Our research is typically engaged and exploratory in nature, because "the phenomenon has to be created before it can be evaluated, which is in contrast to explanatory research" (Holmström et al., 2009). The design science philosophy addresses the identified problem and the research questions that are being formulated.

Research strategy

According to Benbasat et al. (1987) a research strategy considers the line in which a study is conducted. A research strategy is defined as an ordered set of steps being followed, when inquiring into the phenomenon being investigated (Trochim et al., 2001). In choosing a research strategy the nature of the research problem, the objectives, the formulated research questions, and the status of theory development are being considered.

The identified research problem of our study exhibits the characteristics of an ill-defined problem, while the development of prosumer communities is still in its infancy and many complexities and barriers still have to be dealt with. The number of initiatives has grown significantly over the last decade, but only a few seem to be successful, although in ample development yet. Multiple directions for solutions are still optional. Therefore the inductive-hypothetic strategy (Sol, 1982) was chosen as a suitable strategy in the context of engaged research. Inductive-hypothetic strategy is suitable for solving ill-defined problems. It is characterised by inductive reasoning from exploration and understanding to design, following an interdisciplinary approach, generation of alternatives for problem solving in an iterative design process, and interdependent analysis and synthesis activities (Gonzalez & Sol, 2012).

The inductive-hypothetic research strategy is focused on theory formulation and on the generation of alternative solutions, as well as on providing insight into the mechanisms at work. It consists of four consecutive research phases leading from exploration and understanding of a research domain to the design, implementation and evaluation of artefacts (see Figure 2). According to Hevner et al. (2004) design essentially is a quest for the discovery of an effective solution to a problem.

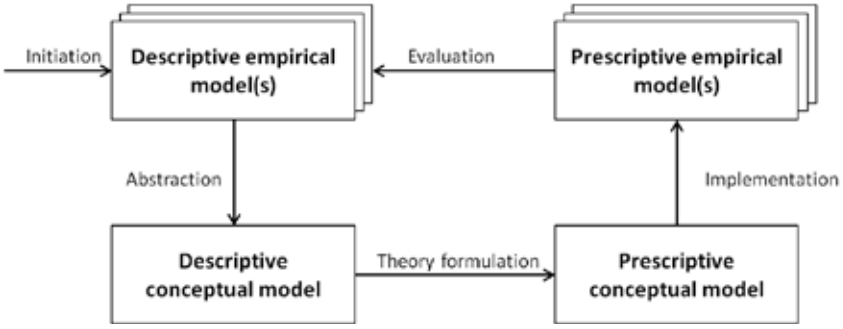


Figure 2: Inductive-Hypothetic Research Strategy (Sol, 1982)

The four phases of the inductive-hypothetic strategy were followed in our research:

1. *The exploration phase:* the aim of this phase was to develop a lens and a clear view on the formulated research problem, leading to the description of an empirical situation (descriptive empirical model). An extensive literature study was performed on the emergence of prosumer communities and on relevant technology developments. The exploration of the application domain was performed by case studies of four Dutch prosumer communities, in combination with two group sessions with prosumer community participants, and interviews with stakeholders from the prosumer communities' value network. The exploration phase provided input for answering research sub question SQ1 on the growth path of prosumer communities.
2. *The understanding phase:* based on the findings of the exploration phase, we made an abstraction of the prosumer communities case studies (descriptive conceptual model), giving us a better understanding of the generic issues that are incorporated in the growth path of prosumer communities and the decisions involved. The research sub questions SQ1 and SQ2 were answered in this phase, uncovering the generic growth path phases of prosumer communities, as well as the requirements involved for enhancing decision making along the growth path.

3. *The design phase:* in this phase the direction of possible solutions for decision enhancement of prosumer communities were elaborated. This resulted in the design of an artefact in the form of a prescriptive conceptual model, which was implemented in a prototype. The design phase covers the answering of research sub question SQ3 of how a solution could look like that meets the formulated requirements.
4. *The evaluation phase*: in this phase the prototype was used to evaluate the perceived usefulness and perceived usability of the designed artefact. The evaluation was executed in three group sessions with prosumer community representatives and in eight individual sessions with experts from the energy domain.

Research instruments

In the four phases of the research different research instruments have been used. The research instruments and their respective outcomes are shown in Table 1.

Table 1: Research instruments and outcomes of the four research phases

Research phase	Research instruments	Outcomes
1. Exploration	- Literature review - Case studies - Group sessions with Group Support System - Stakeholder interviews	- Overview of and insight in the development of prosumer communities and the related challenges
2. Understanding	- Literature review - Analytical-evaluative framework	- Understanding the development of prosumer communities - Abstracted model of prosumer communities growth path phases and insight in the involved decision making processes - Requirements
3. Design	- 'The way of' framework - Prototyping	- Prosumer community shopping mall design - Prototype implementation
4. Evaluation	- Literature review - Group sessions - Expert sessions - Questionnaires	- Testing - Evaluation of the perceived usefulness and perceived usability of the shopping mall artefact

According to Hevner et al. (2004) various instruments can be used in the evaluation phase of a design science research project. We have chosen to use both group sessions and individual expert sessions to evaluate the perceived usefulness and perceived usability of the designed artefact, the prosumer community shopping mall. Questionnaires were filled in by session participants in both the group sessions and the expert sessions.

1.7 Thesis outline

In this section we introduce how the research question and sub questions are addressed, following the structure of the thesis. Basically, the chapters cover the four consecutive research phases of the inductive-hypothetic research strategy that are mentioned in the previous section on research strategy. So, the phase of *exploration* is covered in Chapter 1, 2 and 3, while the *understanding* phase is described in Chapter 4, followed by the *design* phase in Chapter 5 and 6, and finally the *evaluation* phase in Chapter 7. The thesis outline is depicted in Figure 3 below.

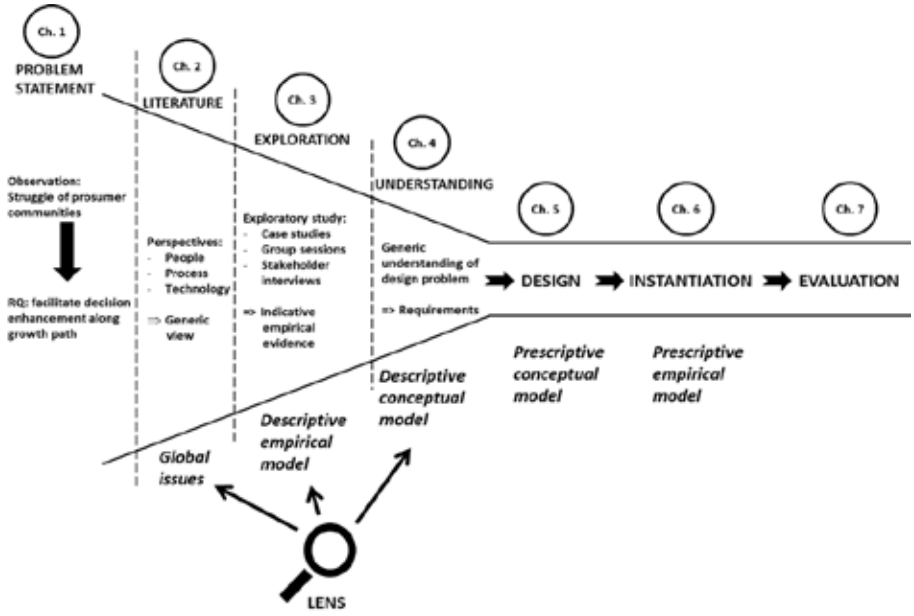


Figure 3: Thesis outline

Chapter 2 describes the development of prosumer communities from the three different perspectives of decision enhancement: people, process and technology. Literature from various academic disciplines is studied to provide a lens from these three perspectives on the phenomenon of emerging prosumer communities: what are people's motives to start-up a prosumer

community or to participate in it, how are these initiatives organised in which contextual environments, and which technological developments are applicable for prosumer communities. Chapter 3 provides the results of the exploratory study that has been performed. Four case studies, along with two group sessions and various stakeholder interviews yielded empirical data, giving us insight in the various activities that prosumer communities in practice have delivered so far, and in the activities that are planned for the future.

Chapter 4 subsequently addresses the sub questions 'SQ1: how does the growth path of prosumer communities look like?' and 'SQ2: what are the requirements of prosumer communities for decision enhancement along their growth path?' In order to do so, the exploratory study results from Chapter 3 are further analysed, leading to a generic understanding of the growth path of prosumer communities, and to pinpoint the actual design problem. Various activities are abstracted, including the identification of the decision making processes that were involved in solving the faced problems. The chapter ends with generic requirements, which have to be fulfilled when a solution is to be developed for enhancing the decision making of prosumer communities along their growth path. The first four steps, each covering one chapter, are depicted as a funnel, indicating this is a process, converging towards the identification of the real design issues (generic understanding of research problem) at the end of Chapter 4.

In Chapter 5 we answer the third sub question SQ3 of how a solution looks like that meets the requirements for decision enhancement by presenting the artefact of the prosumer community shopping mall. The various elements of the shopping mall are further elaborated, as well as the actors that are involved in the shopping mall. Chapter 6 describes the prototype implementation, as an instantiation of the prosumer community shopping mall.

Chapter 7 addresses the evaluation process. It describes how the evaluation sessions were prepared and organised, and how the results were elaborated. The three group sessions with prosumer community representatives and the eight expert sessions were used to evaluate the perceived usefulness and usability of the prosumer community shopping mall.

Finally, Chapter 8 reflects on the main findings of the research and its generalisability, the research rigour and relevance, followed by the research contributions. The chapter concludes with proposing directions for further research.

2 Decision enhancement for prosumer communities

The purpose of this chapter is to discuss the problem statement and sharpen the lens: how and why get people involved in a prosumer community initiative, how are they organised, and which technologies are applicable for prosumer communities. We look at literature from the three perspectives of decision enhancement, to provide scientific grounding for the study, as a starting point for further investigation.

2.1 Perspectives for decision enhancement

The objective of this thesis is to develop a decision enhancement environment that facilitates prosumer communities in order to enhance their decision making. Hevner & Chatterjee (2010, p.17) state that the application domain of design science research consists of "the people, organisational systems, and the technical systems that interact towards a goal".

Keen and Sol (2008) developed the notion of decision enhancement, which can be used for analysing the complexity of decision making processes. They describe the term decision enhancement as "a way to look at dynamic and complex decision making processes, and as a way to significantly enhance the decision making through professional practices that fuse human skills, process and technology." They state that decision enhancement is based on three different, interdependent perspectives, as depicted in Figure 4: people, process and technology.

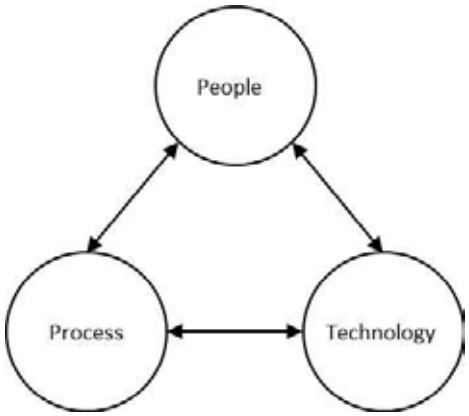


Figure 4: The decision enhancement perspectives (Keen & Sol, 2008)

People make decisions – their skills, values, judgements and experiences shape the decisions. The decision process and the context and environment in which the decisions have to be made influence the likelihood of making effective decisions. Technology can provide multiple types and levels of support to both the people and the process. These three perspectives are used to observe the development of prosumer communities, and demarcate and proceed the research. From these observations we can develop a better understanding of which decisions are involved at different levels and in different contexts. This helps us pinpoint the focus for further exploration (empirical cases in Chapter 3), followed by generalisation (Chapter 4).

This chapter further elaborates the three perspectives on prosumer community development by studying relevant literature. With respect to the people perspective, we look at literature that describes what people motivates to set-up an initiative or to participate in it. With the literature related to the process perspective, we want to deepen our insight in how prosumer communities organise themselves, and in which context this process takes place (e.g. economical, politics, legislation). Finally, the technology that is relevant for the development of prosumer communities is described, both from literature and from a number of (European) research projects.

2.2 People: the actors in prosumer communities

The aim of this section is to identify relevant theories related to the initiators and participants of prosumer communities: who are involved (roles), what are their drivers and motivations. These are important elements that need to be addressed in decision enhancement in order to support prosumer communities.

Walker et al. (2007) studied the social implications of the transition towards a low carbon energy system, where they foresee an important role for local renewable energy projects, and community owned projects in particular. Based on their analysis of projects in the United Kingdom, they distinguished ten different roles for the ordinary people or 'the public' that are involved in renewable energy projects: captive consumer, active consumer, service user, financial investor, local beneficiary, project protestor, project supporter, project participant, technology host, and energy producer. Each role is characterised in terms of spatial proximity, and the degree of awareness and active engagement of the involved people. According to their analysis energy community projects involve at least five of the ten roles: *service users*, *green investors*, *local beneficiaries*, *project supporters* and *project participants*. In

some projects, such as local wind mill installations, the involvement of the role of *project protesters* was also identified. The study of Walker et al. learns us which different roles of potential participants prosumer communities have to deal with, which is relevant for, among others, recruiting participants.
Fischer & Sauter (2004) studied the role of consumers with respect to their acceptance of micro generation4. They concluded that consumers cannot be regarded as one group. They distinguished four groups, each with different attitudes toward, what they call, the diffusion of innovations (Rogers, 1995; Villinger et al., 2000): the first group, *innovators*, are inclined to buy a new product in its introduction phase. In the early growth phase the *early adopters* will purchase the product, followed by the *early majority* in the take-off phase. Later on in the innovation diffusion process, they are followed by the *late majority* and the *laggards* in the maturity phase. Fischer et al. (ibid) conclude that different strategies need to be adapted in order to get the various groups interested, and to turn them from potential participants into active participants.

Walker (2008) identified a number of incentives why different stakeholders want to participate in community owned distributed energy projects. Because the projects potentially generate local income and employment and the participants have a say in the planning and operations, it showed that there was far less resistance and fewer problems involved in acceptance and planning permissions. Next to ethical and environmental commitments, lower energy costs and reliable supply were identified as stimuli, specifically in rural areas, given that upfront costs can be reduced or compensated.

Mobilizing people to join an initiative, like a prosumer community, means that several barriers have to be overcome. According to Bomberg & McEwen (2012) there are three different types of barriers: *psychological*, *technical* and *financial*. The psychological barriers include the lack of accurate information and knowledge, and the feeling that an individual action will not make any difference for the larger whole. Furthermore, incentives for people to participate are low while the benefits of actions - lower emissions, a safer planet, and sustainable energy supply – are rather abstract, and accrue to everyone, not just to the direct benefits of the individual participant. Another related psychological barrier that needs to be tackled is that some people tend to take a free ride on the hard efforts of others. Technical barriers include the lack of equipment and the lack of technical knowledge and expertise. Financial barriers are encountered when people (i.e. prosumer communities) face difficulties in raising sufficient capital for upfront investments, despite the promise of direct or indirect financial gains (e.g. lower fuel bills). Government subsidies can meet this burden. In practice, it is

observed that government policies often prove to be uncertain and inconsistent for the longer term. Notwithstanding these barriers, many prosumer communities persist in pursuing their goals: to realize a sustainable energy system through the reduction of energy usage, and by establishing local renewable generation.

Rathnayaka et al. (2011) identified various parameters that directly and indirectly influence the energy sharing behaviour of prosumers and their willingness to participate in a prosumer community. They developed *the prosumer's energy behaviour framework*, in which they distinguish between internal and external parameters. Examples of internal parameters are the prosumer's energy consumption and generation activities and patterns, their personal preferences (profile), and other contextual factors such as income and budget. External parameters that play a role in the prosumer's energy behaviour are, amongst others, the energy trading possibilities, the provided incentives (e.g. price), the legal constraints, and the technical infrastructure.

Palm & Tengvard (2011) and Stokman (2011) describe that people, who start up a prosumer community, are being driven by various motives. Kindred spirits find each other in their personal drive and start collaborating to get others interested in their initiative. They try to convince them to join, thus creating a broad basis. Their primary motivation is to create a local, sustainable region. There is a strong sense of urgency to accelerate the transition process towards a renewable energy system and they feel that they have to do it themselves. From their perspective the authorities and the incumbent energy companies are only showing intentions (i.e. words) but no actual progress (i.e. actions). Other motives that were identified are the reduction of energy costs in order to prevent energy poverty, to get more control on their own energy provision, and reinforcement of the local economy and local social cohesion. According to Schwencke et al. (2013) societal and social interests are key, while the business case and economical profits are means. Therefore they state that it is important to connect to what might motivate people to participate. Goal framing theory (Griskevicius et al., 2012; Steg, 2008) describes how this connection can be made. Lindenberg & Foss (2011) use the joint production motivation theory to describe the success and failure factors with respect to civilians' participation in community owned projects. Sauter & Watson (2007) describe three different models of consumer participation, which are applicable to the development of prosumer communities. Various authors (Devine-Wright, 2009; Devine-Wright et al., 2007; Musall & Kuik, 2011; Wolsink, 2012; Wüstenhagen et al., 2007) published on public beliefs that play a role in the acceptance of (community) renewable energy projects, like collective wind mill parks.

Resume

This section learns us that various motives and drivers are involved when people start-up a prosumer community. The initiatives have to follow specific strategies to convince people to join their initiative, attuned to the specific role and motivation of potential members, taking into account both psychological, technical and financial issues.

2.3 Process: organising prosumer communities

The purpose of this section is identify approaches and theories that learn us in which contextual environments prosumer communities have to operate. These environments incorporate deployment models, legislation, politics and transition processes, which all influence the prosumer communities' development process.

In the early 1980s the first local community scale energy projects emerged, which were then labelled as "grassroots alternative technology activism projects" (Walker et al., 2007). Only recently, the development of local based energy initiatives is considered to be a serious component of the current and future energy system. The emergence of prosumer communities exhibits a rich variety of initiatives, both in size, composition, and the way they are organised. Walker & Devine-Wright (2008) examined community renewable projects in the UK. They identified two key dimensions that were shared by all projects: *process* and *outcome*. The *process dimension* relates to the composition of the project's value network, which includes the main developers, the actors involved in the daily operations, and key influencers. The *outcome dimension* describes the spatial and the social distribution of the project's outcomes: who benefits in both economic and social terms. The various projects can be plotted on these two dimensions, as is illustrated in Figure 5. A utility owned wind farm project, as an example, can be projected at the bottom left of the diagram. The generated energy is directly delivered to the grid with no direct local destination, while the revenues flow to distant shareholders. In such a project the utility company is both owner, developer and operator of the wind farm. The involvement of local people is limited to the role of customer, i.e. buyer of energy. A community owned solar panel field can be plotted in the upper right hand corner. Such a project is fully organised and operated by local people, while the benefits (both energy and money) are collectively shared within the local community. In general, prosumer community projects can be projected in the upper right quadrant. Depending on the specific emphasis on the degree of local involvement or the distribution of benefits, the initiatives are allocated high on the process axis, respectively high on the outcome axis.

Process and outcome can be used to categorise various sustainable energy projects. Prosumer community initiatives, as subject of our study, can be categorised in the top right hand quadrant: open processes, with a high level of participation, where the outcomes are locally distributed and collectively shared.

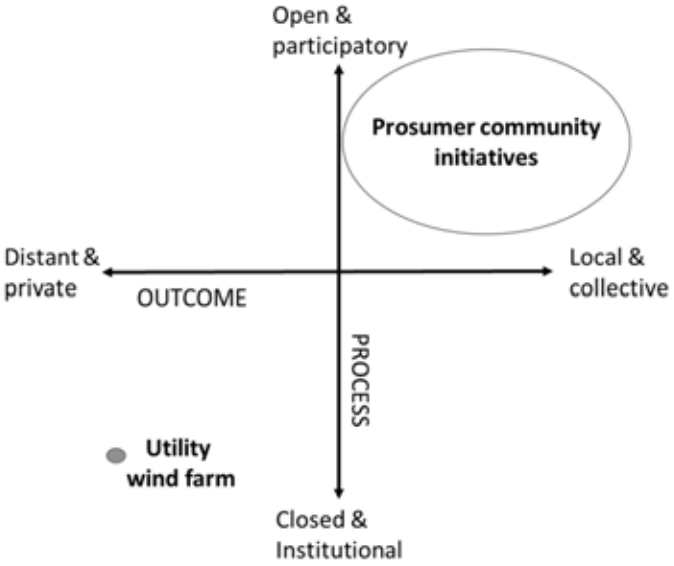


Figure 5: Community renewable energy projects in relation to project process and project outcome (derived from Walker & Devine-Wright, 2008)

Watson et al. (2008) describe three possible deployment models for micro-generation technologies: *the plug-and-play model*, *the company driven model*, and *the community micro grid model*. Each of the deployment models is associated with new roles energy consumers can play in the energy system (Watson, 2004): the role of *co-construction*, *co-production* and *co-provision*. In the *plug-and-play model* the individual consumer is fully in control as owner, financer and manager of the generation facilities. The *company-driven model* involves a more passive role of the consumer as provider of the site for the generation facilities, while the facilities are owned and operated by the energy company or an energy service company (ESCO). The *community micro grid model* is the third (Watson et al., 2006), where the micro-generation units are connected to a local micro grid. In this model the consumers have the primary control over their units, as in the plug-and-play model, but they also contribute to the supply-demand balance within the micro grid, thus increasing economic viability. Table 2 shows the advantages and disadvantages of each deployment model, how each model links to the consumer's motivations, and to which extent the model helps to overcome barriers for the acceptance of micro-generation technologies. The community

micro grid deployment model is closest to prosumer community initiatives, which learns us about the involved motivations that have to be addressed, next to problems that need to be solved in the development process.

Table 2: Different deployment models from a consumer perspective (Watson et al., 2006)

Consumer perspective	***Deployment model***		
	Plug and Play	**Company Driven**	**Community Micro Grid**
Motivations			
- Independence	+	-	+/-
- Technological interests	+	+/-	+/-
- Being green	+	+	+
- Hassle free provision	-	+	+/-
- Reduced energy bill	+	*	*
Barriers			
- Lack of access to capital	+/-	+	+/-
- Risk aversion	+/-	+	+/-
- Scepticism of new technologies	-	+	+
- Lack of information and knowledge	-	+	+

**Depends on the contractual arrangement.*

Watson et al. (2006) conclude that consumers' patterns of energy consumption can be stimulated by favourable fiscal regulations. Another incentive for energy behavioural change can be the extension of the settlement system, in such a way that the surplus of generated energy can be sold at real-time market prices. This way, a level playing field for micro-generation on the energy market is created. Having a level playing field is relevant for prosumer communities to be successful. Fiscal, financial and regulatory incentives play an important role. As an example, in 2012 the UK government introduced a new type of company called the Community Interest Company (CIC). The CIC company type makes it possible to easily set up a business or other activity, which incorporates some special features to ensure that they are beneficial for the community.

Bomberg & McEwen (2012) investigated 100 prosumer communities in Scotland, because they wanted to know how groups do mobilize people to participate in a local energy project. To their opinion groups have to mobilize both material resources such as money, skills and expertise, as well as non-material resources or symbolic resources, such as identity, authority and the quest for autonomy. Symbolic resources such as shared goals can be helpful to

entice people to join. The findings of the study showed that state support for community initiatives, both in financial and political sense, was a crucial motivator. All cases showed evidence that both the symbolic resources of identity and the quest for greater autonomy were the main drivers for the mobilization of energy community groups. The generation of local income proved to be an imperative for more independency, and thus creating greater autonomy.

In their examination of community energy projects in the UK Seyfang et al. (2013) identified five critical success factors, each correlating with different levels of activity: 1) *the group*: having key committed individuals that drive a project forward in an effective organising group that is capable of maintaining momentum and overcoming setbacks; 2) *the project*: availability of sufficient time, information, skills, money and material resources are necessary to carry out the project, while financial viability is relevant; 3) *the community*: the project needs to be designed so that it meets the community's needs, in order to establish engagement and trust with the community; 4) *the network*: forming supportive partnerships and information-sharing networks with other groups, and; 5) *the policy*: a supportive national policy context is necessary.

Diversity is characteristic for innovation processes, as is described in transition management and inverse infrastructures theories. In literature on transition management theory (Loorbach & Rotmans, 2010; Verbong & Geels, 2007; Walker et al., 2006) the emergence of prosumer communities is seen as a typical example of a niche activity and bottom-up movement. Hoogma et al. (2002) define a niche as "a discrete application domain where actors are prepared to work with specific functionalities, accept such teething problems as higher costs, and are willing to invest in improvements of new technology and the development of new markets." According to Seyfang & Smith (2007), "niche-based approaches explore problem-framing (e.g. mobility, food, energy services) and search for solutions, in contrast to technology demonstration projects that begin with 'technical solutions' tightly framed problems." Niches potentially can realize a radical change in existing regimes, such as the energy system, where large incumbent companies with vested interests still play a dominant role. Seyfang & Smith (ibid) observe that niche innovations are mostly operating in the context of the market economy, in contrast to grassroots innovations that exist within the social economy of community activities and social enterprises. They introduce a research and policy agenda to link both worlds. Transition management theory describes which preconditions have to be met to make such bottom-up movements successful. Success in this context means that the role of prosumer communities in the energy system has to be encoded into the institutional arrangements. The

authorities, as a rule issuing body, play a crucial role as enabler and stimulator of transition processes, by creating protected spaces through institutional design and providing subsidies. The (temporarily) created protected spaces give room for experiments that otherwise would have been blocked by existing legislation.

Verbong & Geels (2010) describe three possible transition pathways towards a sustainable energy system. The *transformation pathway* stays closest to the current situation, while there is still a strong focus on central production with a central coordination mechanism. The *reconfiguration pathway* involves an up-scaling of the energy system up to a European level, with large-scale central production, with strong interconnections between the various national grids, and a centralised management and control mechanism at European level. The *de-alignment and re-alignment pathway* illustrates the emergence of prosumer communities, where there is a strong emphasis on regionalism, community-based organizations and local autarkic energy systems. They conclude that the de-alignment and re-alignment pathway scenario is less likely than the other two pathways, while the latter two stay closer to vested interests, as well as being more in line with, as what they observe, the on-going dynamics. From the viewpoint of grid operators, prosumer communities do not yet play a major role in the energy system balancing market (Schwencke et al., 2013). One of the conclusions from an intermediate review of the German energy transition process (Agora, 2013) is that a strongly interconnected and integrated international energy system is likely to be more efficient than optimising demand and supply at a local, regional or national level. The review (ibid) considers local and regional markets as an intermediate solution before an integrated European market will be realised.

Pront-van Bommel (2012) describes in detail which barriers the current Dutch legislation raises for the development of prosumer communities. Watson et al. (2008) describe the political component and legislation in a broader context, where they also include economic considerations. Schwencke (2012) describes which different legal organisational forms can be applied for prosumer communities. Which legal form is best suited strongly depends on local circumstances and the goals that are being pursued. AgentschapNL (2010) indicates which different roles authorities, both at a national, regional and local level can play in the development process of prosumer communities.

Resume

This section learns us that prosumer communities are part of the larger context of the energy transition process. The bottom-up process can only be successful when changes at all levels in the energy system are effectuated. These changes incorporate legal issues, fiscal and financial regulations, as well as changes in the energy market model. Prosumer communities can adopt different deployment models, depending on their goals.

2.4 Technology: applicable for prosumer communities

Technology and technological innovations play an important role in the transition process to a sustainable energy system. The following section describes various technology developments that are of relevance for prosumer communities. First a number of distributed energy generation technologies are described that can be employed in prosumer communities. Smart grids cover the upgrade of the current energy infrastructure into an intelligent network. Smart coordination mechanisms are needed to enable the interaction between the various smart grid components. Finally, the smart energy technologies section describes the technologies that are applicable at the lowest level in the energy system: at both the community and household (e.g. appliances) level.

Distributed energy generation

Distributed generation is the production of energy by units that are connected to the distribution network or to a customer site. Distributed generation can be categorised by both the size of the production units (large scale, medium or small-scale), and the type of energy source that is being used (fossil or renewable). Table 3 shows the categorisation as is described by Ten Donkelaar & Scheepers (2004). Mainly distributed generation is relevant for prosumer communities.

Table 3: Categorisation of distributed generation (Ten Donkelaar & Scheepers, 2004)

	Combined Heat and Power	**Renewable Energy Sources**
Large-scale Generation	- Large district heating - Large industrial CHP	- Large hydro - Off-shore wind - Co-firing biomass in coal power plants - Geothermal energy - Concentrated solar power
Distributed Generation	- Medium district heating - Medium industrial CHP - Utility building CHP - Micro CHP	- Medium and small hydro - On-shore wind - Tidal energy - Biomass and waste incineration - Biomass and waste gasification - PV solar energy

Distributed generation that is attuned to local demand load can defer expensive upgrades and extensions of the physical infrastructure. Potentially, high penetration of renewable distributed generation can also have negative impacts on the proper functioning of the network. Passey et al. (2011) reviewed both the positive and the possibly negative impacts. For the negative impacts they describe which possible technical approaches are available to address them.

How distributed renewable energy generation can be applied in small remote-area communities is described by Khan et al. (2007). They developed a community-based energy model, where the locally available natural resources are utilised as a source for generating sustainable energy with locally available facilities, thus trying to realise zero-waste living for local communities. The model was tested in a small community in Canada. The researchers claim that the model is applicable worldwide, especially in remotely located communities, where electricity grids are not always available or only in a limited way.

Smart grids

The European Union has set ambitious goals for a future, sustainable energy system. By the year 2050 greenhouse gas emissions must be reduced by 80%, while the energy production will have to be almost carbon-free. The European Technology Platform for the Electricity Networks of the Future (SmartGrids, 2012) laid down the EU smart grid research agenda, which has to develop the

solutions that cover these long-term goals. The key driver for smart grids is to "ensure that by 2035, Europe's electricity networks continue to function in a manner that optimises cost and environmental performance without giving up traditionally high security and quality of supply, while hosting a very large and further increasing penetration of renewable generation." The future network should provide, amongst others, communication technologies that enable efficient and low costs information exchange between all stakeholders in the electricity systems, down to the consumer.

According to Netten (2011), a robust information architecture is needed for realising a future proof intelligent energy infrastructure. The information architecture describes an ICT infrastructure, which provides an extra layer on top of the existing energy grid. This ICT infrastructure, referenced as *The Energy Internet*, provides the monitoring and control interfaces, which can be used for measuring and operating production, consumption and storage facilities. These interfaces function as an abstraction layer, which covers the complexity of the underlying energy grid, and it enables parties to develop all kinds of new energy services on top of it. The need for standardisation is a key issue in order to guarantee interoperability between the various components. According to Bouffard & Kirschen (2008) this is still a pressing issue. Kok et al. (2010) state that the future networks need bottom-up control and distributed coordination. Such an intelligent distributed coordination mechanism aligns the power system with communication network technology, as well as with computer hardware and software in shared information architectures.

Until 2020 the Dutch grid operators do not expect any significant problems caused by the prospected growth rate of renewable sources, like solar PV and large and small-scale wind mill installations. The current network has enough capacity to meet the expected volumes (Schwencke et al., 2013). Grid operators have to balance the arguments of investing in capacity extension of the infrastructure, against investing in smart technologies that will increase the efficiency of the current infrastructure (Van Dril et al., 2102). For the inclusion of distributed renewable energy generation, the focus is on upgrading the distribution networks. Demand and supply patterns need to be controlled and managed at a local level, in order to keep the peak load within the boundaries of the available capacity. Load management can be implemented at various levels:

1. Balancing supply and demand *behind the meter* (e.g. within end-users' premises).
2. Load shedding by temporarily switching-off local generation facilities.

3. Demand response programs, where energy consumption is attuned to the moments of favourable conditions (e.g. price, availability of sustainable energy) and the (local) network load.
4. Energy savings projects.
5. Local energy storage, which can be used to spread supply and demand in time in order to avoid peak loads.

There are numerous European research projects, stimulated by the European Union, that focus on the various aspects of smart grid development. Some of them are focussed on local energy initiatives, such as the IMPROSUME project (Shandurkova et al., 2012). The project evaluated a number of studies on the development of a market model for smart grid projects that enables the integration of prosumers in the energy market. Grijalva & Tariq (2011) propose a new architecture for the electricity infrastructure, which they call the prosumer-based smart grid architecture. It is a layered architecture, where the prosumer is physically modelled as a combination of components (energy sources, loads and storage) and an electricity grid. Each layer is agnostic about the implementation of the other layers, thus providing a modular and scalable architecture. The interaction between the different layers is based on service interfaces. Based on this layered Service Oriented Architecture (SOA), new services can be provided for generation, storage, and exchange of energy at multiple levels in the energy system.

Smart coordination mechanisms

There is a considerable amount of research that proposes solutions, mostly technical in nature, for the integration of distributed generation facilities, smart homes, and prosumer communities into the energy system, in order to realise a future-proof energy infrastructure (Melo & Heinrich, 2011; Mercurio et al., 2012; Pagani & Aiello, 2011; Steinheimer et al., 2012; Vogt et al., 2010). In this section the PowerMatcher is used to illustrate the working principles of a smart coordination mechanism. Other coordination mechanisms are available, using different algorithms, but basically they follow the same basic principles of real-time matching of demand and supply.

To guarantee security of supply of the future energy system, in particular within a prosumer community, a new way of coordination is needed which facilitates that the demand for electricity follows the supply as much as possible. A typical example of such a smart coordination mechanism is the PowerMatcher technology, see Kok (2013). The PowerMatcher couples the flexible demand of individual end-users (e.g. households) to the flexible availability of (local) supply. By collecting the demand and supply patterns, the PowerMatcher generates an optimal operation schedule for the balancing of

demand and supply. This schedule is send to the end-users, where it is used to manage and control the operation of individual appliances (e.g. heat pump, freezer, micro-CHP, electric vehicle). In this way, the end-user can act as a supplier of flexibility services in for instance a prosumer community.
The PowerMatcher mechanism was field tested in several pilot projects, like PowerMatching City (Bliek et al., 2010) in the suburb Hoogkerk of the city Groningen, the Netherlands. Forty households were equipped with controllable home appliances that were coordinated by the PowerMatcher. When cheap electricity is available, heat pumps start running to produce heat, which is stored in a 210 litre heat storage tank at the participants' premises for later use. The project participants partly produced their own electricity by solar panels and micro combined heat and power units (μCHP), where they could exchange energy with each other on a local energy market. Field tests proved that in a smart prosumer community smart coordination of heat and electricity producing systems (i.e. heat pumps, μCHPs) and loading electric vehicles, can reduce the daily peak load of the local distribution grid with 30% to 35% (Kok, 2013).

Smart energy technologies

The EU NOBEL project (Karnouskos, 2011a) studied how a community-aware smart grid can be developed. They propose a flexible service infrastructure, which provides near real time status information of all community members and the energy related appliances (both generation and consumption). Based on this status information all kinds of value added services can be developed and provided. Example services are real time energy monitoring, real time billing, device management, and local balancing of supply and demand.

On a community level, it is important to coordinate the energy management systems of all the connected participants. The exchange of energy, for optimally balancing demand and supply, follows three stages: 1) self-supply, using the self-generated energy, 2) exchange of surplus and deficiencies within the community, and 3) exchange of surplus and deficiencies with the traditional energy companies. The European ADDRESS project (Belhomme et al., 2011) investigated how a commercial and technical framework can be developed that provides active demand response in the future smart grids. Demand response services enable domestic and small commercial customers to actively participate in the energy market. As Karnouskos (2011b) concludes, there is much attention for the development of energy related services and applications from the perspective of the grid operator, while services that support the development and operation of local energy communities are still in an embryonic stage.

Based on their prosumer's energy behaviour framework, as described in Section 2.2, Rathnayaka et al. (2011) propose an agent-based architecture for prosumer communities, which enables the autonomous interaction between the various active components within the community. They identify two main modules: 1) the prosumer home module, representing the individual prosumer, and 2) the community operation module, which acts as the community's smart gateway to all the participating prosumers and external parties. The various components that play a role in balancing the energy streams within a prosumer community are represented in Figure 6 below.

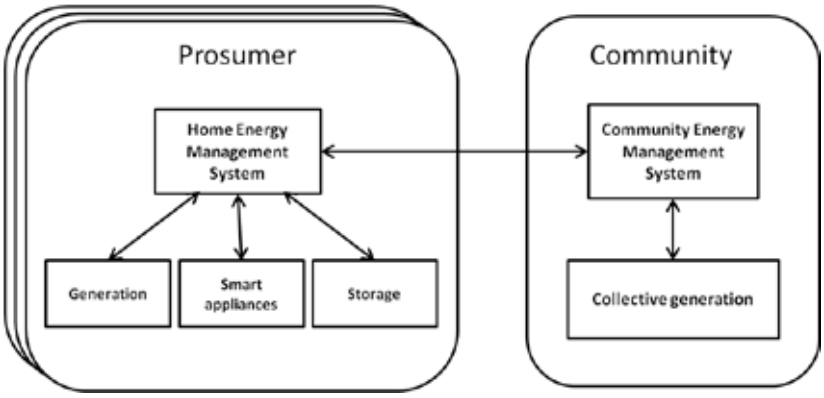


Figure 6: Prosumer community active energy components

The various components in Figure 6 can be subdivided into a number of categories, depending whether or not they can be controlled and managed, as is described in Table 4.

Table 4: Prosumer community components categorization (Flexines project, Lely et al., 2012)

Category	Supply/demand	Description
Controllable generation	Supply	The output of these generation facilities can be controlled, providing flexible supply. Both at household (e.g. micro-CHP) and community level (e.g. biomass fired CHP).
Non-controllable generation	Supply	Renewable energy generation (e.g. PV, wind) cannot be controlled.
Controllable appliances	Demand – time shift	The operation of (smart) appliances (e.g. washing machine, dish washer) can be shifted in time based on the user's preferences, a forecasting model, or external real-time control signals (e.g. prices, availability of sustainable energy).
Controllable appliances	Demand – thermal buffer	Thermal buffers contain a heat capacity (e.g. fridge, freezer, central heating boiler, micro-CHP, heat pump), which operates between a lower and upper boundary. This flexibility range can be used for demand shift.
Non-controllable appliances	Demand	The load of these appliances and devices (e.g. light, TV) cannot be managed, thus generating a base load.
Storage	Supply & demand	Surplus energy can be stored, both at a household level (e.g. electric car, heat boiler) and at community level (e.g. battery system, CHP heat storage). The stored energy can be used in case of shortage.

Smart meters introduce a new means of communication facilities between the energy grid operators (DSO) and consumers. The smart meter operates as an interface between the grid and the house. The grid operator gets valuable information on the status of the network, while the consumer is provided with real time information and feedback on his energy consumption, thus creating awareness as a potential stepping stone towards behavioural changes.

The smart meter also facilitates the introduction of a variety of value added services, based on actual metering data (Watson et al., 2006).

Smart homes and energy behaviour

The term smart home refers to the use of ICT technology in the home to facilitate the interoperability of household products and services in a built environment (Peine, 2008). The development of smart home technology goes way back to the 1980's, but until now a market break through still has not been realised. The high attention for the integration of renewable generation facilities in the distribution networks attracted renewed interest in smart home technology. Individual home appliances and devices are equipped with sensors and communication facilities, which can be connected to a central in-home energy management system (EMS). The EMS dashboard gives consumers detailed insight in the energy consumption at the level of individual home appliances and it enables them to better monitor and control their energy behaviour. By setting preference profiles and giving permission to an external operator (e.g. retailer, ESCO, prosumer community) the energy control and operation of the related appliances can also be automated.

Within the European project SmartHouse / SmartGrid (Kok et al., 2011) an ICT architecture was developed that enables smart homes to interact with smart grids. The architecture was implemented and tested in three field trials in different countries. Within each trial they experimented with a cluster of smart homes, where they tried to automatically aggregate control of end-user systems, while high-volume data traffic was being generated.

Kobus et al. (2015) studied whether the design of energy management systems (EMS) affects the sustainable energy-saving behaviour of households. In a longitudinal field study among a large group of Dutch households, they tested two EMSs with different designs, and compared them with a control group, to explore the effects of the design on domestic energy consumption (both electricity and gas). The study showed that just providing real-time feedback is insufficient, but that use frequency of the EMS supported energy savings. The results indicate that frequency use of the EMS is stimulated by providing a design with high accessibility and ease of use, thus leading to the desired sustainable energy-savings behaviour.

Geelen (2014) used the PowerMatching City pilot project to investigate how end-users can be supported in their new role as prosumers in the energy system by offering them various energy products and services. For that purpose, in the second phase of the pilot project a user interface (i.e. an EMS) was developed in a co-creation process with the end-users. The EMS

dashboard provided the participants with better insight in and control over their energy system, which proved to be supportive for the participants in their role as prosumer. Geelen (ibid) concluded that for the development of product-service combinations for prosumers, a balance is needed between, on the one hand structural solutions via technical systems and, on the other hand the involvement of end-users based on their needs, goals and capacities.

Resume

This section explored which energy related technologies are relevant for prosumer communities. Various technology components already are available, while other components are still in an experimental phase. Pilot projects show the potential of the new technologies for saving energy and influencing behaviour and empowering end-users. Tools and services offered to end-users should have a low threshold and should be easy to use. This can be realised by a co-creation process with end-users in order to obtain long-term sustainable energy behaviour. The technologies and related tools potentially are part of the service offering to prosumer communities.

2.5 Summary

This chapter describes a literature review from the three different perspectives of decision enhancement, creating a lens on the development process of prosumer communities. It shows that the emergence of prosumer communities, as part of the energy transition process, can be followed from various scientific disciplines, such as psychology, sociology, transition management, energy technology, information technology, etc. Various aspects that touch the three aspects of decision enhancement - people, process and technology - are being highlighted. But still, an integrated approach, that covers the full range of decision making along the prosumer communities' growth path, is lacking. As Walker (2008) and Rotmans & Horsten (2012) stated, prosumer communities need to be facilitated in getting access to knowledge and expertise related to the complexities of the energy sector, which is mostly lacking. Forrest & Wiek (2014) advocate the necessity of many more studies to build an empirical database to better understand the key success factors for the full development of, what they call, "grass root initiatives".

In the next chapter we describe an exploratory study in order to identify the various growth path phases, which decision making processes are involved in solving problems, and what are the needs and demands of the prosumer communities for enhancing decision making.

3 Exploration of prosumer communities

This chapter describes the results of the exploratory study, which includes four real-life prosumer community case studies, two group sessions with individual prosumer community participants, and forty seven interviews with various people that are part of the prosumer communities' value network. The exploratory study, as part of the design science approach, yielded empirical data on the various activities that the prosumer communities have carried out so far and their planned activities for the future. These activities give us insight in the prosumer communities' growth path and the problems and complexities encountered.

3.1 Exploratory study

In the next step toward the identification of the real design issues, we conducted an exploratory study consisting of case studies with four real-life prosumer communities, next to two group sessions with prosumer community participants. Furthermore, stakeholders from the value network of prosumer communities were interviewed. Table 5 shows an overview of the exploratory study, including the research instruments that were used, which participants were included, and the number of respondents.

Table 5: Overview of the exploratory study

Research instruments	Participants	Number of respondents
Case studies	Representatives from four prosumer communities	8
Group Support System sessions	Individual prosumer community participants	30
Interviews	Stakeholders related to the prosumer community value network	47

The case studies, with representatives of four prosumer communities, were conducted to get insight in the growth path of prosumer communities so far, which activities had been carried out, and which problems were encountered. The group sessions and interviews were meant to collect additional information that could support and supplement the results of the case studies, and deepen our understanding of the problems at stake. The goal of

the group sessions was to explore which demands and needs individual participants (mostly households) would have with respect to supportive services. Furthermore, the stakeholder interviews, with a variety of value network stakeholders, were aimed at collecting their view on the emergence of prosumer communities and their role in the energy system. The case studies are further described in Section 3.2, the group sessions in Section 3.3, and the stakeholder interviews follow in Section 3.4.

3.2 Case studies

By the end of 2016, 256 local energy cooperatives were identified in the Netherlands that in some form strive to realise a sustainable energy provision at a local level (Schwencke, 2016). As part of the research strategy that was followed, four prosumer communities were selected for the case studies, based on the criteria shown in Table 6 below. The case studies were aimed at collecting indicative empirical evidence for the identification of activities and growth path phases, next to identifying encountered problems where decisions were involved.

Table 6: Prosumer community case study selection criteria

Criteria	Description
Citizen initiated	The prosumer community is initiated by citizens
Energy focussed	The prosumer community aims for sustainability goals with a specific focal point on energy
Development status	Should have been active for at least 2 years and should have deployed a substantial amount of activities
Rural and urban environment	Initiatives from both rural and urban environments are represented
Smart grid pilot	Should be involved in a smart grid pilot project

The first two criteria are based on the definition of prosumer communities that was formulated in Chapter 1. The selected initiatives had been active for a longer period of time so they could provide more input based on their gained experience. When the cases studies were started, not many initiatives were that far in their development process. The rural/urban criterion was included in order to cover both aspects, while the possibilities for implementing energy projects differs due to environmental conditions.

The smart grid criterion was included for the very reason that it is an indication of frontrunner initiatives. It also was interesting to identify which services were being deployed and experimented within the pilot projects, as a glimpse into the future growth path of prosumer communities, and possibly providing potential tools and services for the to-be-designed decision enhancement environment. People, process and technology are all being addressed in the case studies.

Based on the given criteria the initiatives TexelEnergie, Grunneger Power, LochemEnergie and Zeenergie were selected. All selected prosumer communities are citizen initiated, bottom-up initiatives and are considered to be front runners. TexelEnergie and LochemEnergie are both located in rural areas, where Grunneger Power typically represents an urban prosumer community initiative. Zeenergie is unique in the combination of an urban area of the city of Zeewolde and a large surrounding rural environment with a high concentration of wind and biomass energy production capacity. Furthermore, all four initiatives were involved in a smart grid pilot project, which was specifically interesting for our case studies. The experiences gained with the future grid technologies and related experimental energy services, could provide us a glimpse of how prosumer communities might operate in the future, thus uncovering a part of their potential future growth path.

Smart grid pilot projects

Each of the smart grid pilot projects was subsidised by the Innovation Platform for Intelligent Networks (IPIN) program of the Dutch ministry of Economics, Agriculture and Innovation (EL&I)[7]. The IPIN program finances pilot projects, where room is given to experiment with new technologies and new business models, as well as to experiments with partnerships and institutional arrangements that explore the frontiers of the current legislation. The IPIN program is part of a broader law making track called STROOM that aims to revise the Dutch Electricity and Gas Law, which stems from 1998. In the end, the experiences gained in the pilot projects should lead to new legislation, which optimally supports the transition towards a sustainable energy system (Schwencke et al., 2013). By creating a minimally regulated space for pilot projects frontrunners, such as the four selected prosumer communities, are facilitated to experiment with innovative activities that stimulate the transition process, which otherwise would be hindered by the current regime (Loorbach & Rotmans, 2010).

[7] http://www.agentschapnl.nl/content/factsheets-12-experiments-intellligent-networks-february-2012.

Table 7: Selected case studies and the related smart grid pilot projects

Prosumer community	**Smart grid pilot project**	**Project partners**
TexelEnergie	Cloud Power Texel	CapGemini, Liander, Quby, Siemens
Grunneger Power	PowerMatching City phase II	DNV GL, Enexis, Essent, ICT automatisering, TNO, Delft University, Eindhoven University
LochemEnergie	IN4energy	Eaton Industries, Locamation, Alliander, Twente University
Zeenergie	INZET	ProXenergy, Sternweg, Van der Knaap, Alliander, GreenChoice, Delft University

The four prosumer communities were approached via telephone or e-mail in order to find the right person(s) who could be interviewed. We used open and half structured interviews, with a topic list as a checklist for the subjects that should be addressed (see Appendix 2). Each of the interviews was worked out in a separate summary report. In some cases more than one person was interviewed, or multiple interviews with the same person were conducted in the course of time. Next to the interviews, other resources such as websites, newsletters, articles in press and annual reports were used to collect information on the prosumer community's activities, their plans and developments.

The following sections describe each of the four prosumer community case studies, based on the following topics that cover the people, process and technology perspectives of decision enhancement:

- History
- Formulated goals
- Organisational form
- Energy supply
- Activities carried out
- Future plans
- Deployed and projected energy services

Case study I - TexelEnergie

History

The island of Texel in the north of the Netherlands has a population of almost 14.000 inhabitants and 6.000 households. During the holiday seasons the number of inhabitants is a multitude: in 2013 there were almost 700.000 visitors[8]. TexelEnergie, founded in the year 2007, was one of the first Dutch energy cooperatives. It has grown to one of the largest Dutch prosumer communities with approximately a fourth of its inhabitants being a member. TexelEnergie is regarded as an exemplar and frontrunner for other prosumer communities.

Formulated goals

The goal of TexelEnergie is to provide sustainable energy for their customers, both consumers and businesses. As a non-profit organisation it invests the generated revenues in local sustainable energy projects, making use of the local available potential resources (solar, wind, biomass, tidal energy, thermal heat). TexelEnergie also wants to stimulate energy savings. TexelEnergie wants to contribute to the goals that are set by the municipality of Texel to become self-supportive for electricity in 2020.

Organisational form

TexelEnergie is a cooperative with a non-profit goal. TexelEnergie chose the cooperative form because it wanted to create high engagement by giving each member an equal say in the organisation. Each member pays a minimal annual fee of € 50,-, which pays for one share of TexelEnergie. Every shareholder has one vote in the cooperative, regardless the number of shares owned. Members also get a discount on energy supply when they become customer of the TexelEnergie energy company. TexelEnergie opened an office annex shop in Den Burg where people can find information and get advice on all energy related activities.

Energy supply

The cooperative first started with the purchase of green electricity via a waste processing company. Because this company could not provide green gas, they switched to another retailer that could deliver both sustainable electricity and gas. In 2013 TexelEnergie, in cooperation with the wind cooperative WindUnie and the Urgenda foundation, established the umbrella cooperative DE Unie

[8] http://www.texel.net/nl/voor-de-pers/wist-je-dat-van-texel/. Last accessed 8 May 2015.

(Duurzame Energie Unie)[9]. DE Unie now facilitates the energy supply, as well as the invoicing and billing, the financial administration, the support desk and all communication related activities. DE Unie is a non-profit cooperative that offers its services to local energy cooperatives via its shared service centre. By the end of 2016, 26 local energy cooperatives purchased their energy via DE Unie (Schwencke, 2016). TexelEnergie itself produces sustainable energy via solar panels and a biomass fuelled heat stove.

Activities carried out

TexelEnergie invested in various local sustainable energy projects. With its PV-lease project, TexelEnergie rents roof space from companies and private households for solar panel installations for a period of fifteen years. During the lease period TexelEnergie is responsible for the maintenance of the PV installations. This way the owner is fully relieved. The generated energy is supplied to the building occupants as much as possible, while the excess energy is delivered to the other customers of the community. After a period of fifteen years ownership of the solar panels is handed over to the occupants, who then can profit from the generated energy for many more years. TexelEnergie also runs a program for collective purchase of solar panels, including installation of the panels, for both private households and businesses.

In May 2014 a biomass stove started to operate, which provides heat via a heat pipe network to 93 social rented homes in one of the neighbourhoods on the island. The heat network is owned by the social housing corporation. The stove is fuelled with wood pellets, but in the course of time the wood pellets will be supplemented with, and eventually replaced by prunings. The prunings originate from regular forest maintenance on the island, which otherwise would have to be transported to the main land. Other activities of TexelEnergie include a project on energy savings with LED lamps, and heat scans of buildings with a thermal camera. Cooperative members can also use one of the three temporarily available electric vehicles, with only one condition: on return the car must be fully charged.

Future plans

Plans are made to realise a solar field consisting of 3000 solar panels. Several suitable locations have already been identified and financial funding has been arranged. The implementation is still awaiting the finalisation of the permit appliance procedure. TexelEnergie investigates the opportunities for the

[9] See the respective websites: http://www.windunie.nl/, http://www.urgenda.nl/, http://www.duurzameenergieunie.nl/

production of wind energy, although the environmental planning policy imposes the necessary restrictions. Furthermore, a research project is started in collaboration with a number of companies and the municipality of Texel, to investigate how a smart heat storage system can be implemented that can cover the unbalance in supply and demand of solar thermal energy production. Plans for a bio-digester were cancelled, because a study showed that the island of Texel itself cannot provide sufficient raw materials for the digester, and importing these from the mainland was not considered to be a sustainable option. The feasibility of other possible sustainable sources, such as tidal energy and thermal heat are being studied.

Deployed and projected energy services

In April 2012 TexelEnergie started to implement the project *Texel, smart self-supportive*, as part of the Cloud Power smart grid pilot project. The Cloud Power concept adapts the energy demand to the locally generated energy. The field trial with 300 households was kicked-off in February 2014, and ended after 9 months in December 2014. The project participants were provided with an energy managements system (De Kiek!) that gave them insight in their energy usage and eventual energy generation. The system showed the energy prices for the next 24 hours, which were based on the forecasts of the expected amount of locally generated energy. The price incentive was meant to trigger users to adapt their energy consumption to the most favourable moments. Users could set goals that they wanted to reach, like favourable tariff schemes when to use energy, or the yearly budget they wanted to spend on energy. The system gave the users feedback on the status of their targets. The energy consumption of individual home appliances could be made visible by using smart plugs. Based on the collected data, the energy management system provided individual advices on possible energy savings. The first results of the pilot indicated that providing users with insight actually did lead to energy savings (7% on electricity and 14% on gas)[10]. Giving advice resulted in extra insight but did not noticeably lead to extra energy savings. A minority of the participants showed willingness to shift energy consumption, based on flexible energy tariffs, from peak moments (i.e. high tariffs) to moments when (sustainable) energy was available (i.e. low(er) tariffs).

The Cloud Power concept was developed by Capgemini in cooperation with the Quby intelligent home energy management system and Siemens' central

[10] A summary of the first evaluation results are shown on:
https://www.youtube.com/watch?v=LIfv4mbBv3k. Last accessed 20 February 2015.

energy management system. Liander participated as the network operator, who also provided the smart meters[11].

Case study II - Grunneger Power

History

The city of Groningen is with 200.000 inhabitants the main city centre for the northern Netherlands region. Grunneger Power was established in April 2011 as a sustainable energy cooperative for the citizens of the city of Groningen, and its neighbouring municipalities Haren and Ten Boer, totalling 226.000 inhabitants and more than 126.000 households.

Formulated goals

The goal of Grunneger Power is to empower citizens, organisations and companies to generate their own sustainable energy, as individuals but specifically in a collective way. The aim is to stimulate the production of local generated sustainable energy from sun, wind, biomass and geothermal heat.
Besides sustainable energy, the aim is to generate *social energy*, as well as stimulating local economic activities. The foreseen growth path is that 10% of the households of Groningen, Ten Boer and Haren (i.e. 13.000 connections) will become customer[12] of the cooperative energy organisation. Next to individual households, membership of the cooperative is also open for small scale initiatives such as foundations and VVE's (Dutch, meaning association of corporate housing apartments), and for companies.

Organisational form

In the first period of Grunneger Power the cooperative was managed by a board of volunteers. Later on, when the cooperative started to grow and professionalization was needed, a director was appointed, and some of the administrative staff received a fee. Each of the members has an equal vote in the cooperative, where foundations, VVE's and companies only have one vote each. Each member pays a small fee (€ 10,- per year), which covers for the minimal costs of the cooperative. The board is supported by a so-called *do-and-think-tank*. The members of this team are experts from various companies and organisations, who put in their specific knowledge and expertise on a voluntary basis, while they also act as an advisory board for the board of Grunneger Power. The business model of the cooperative is based on

[11] See also: http://www.texelenergie.nl/partners/110/

[12] Next to member of the cooperative, people can be become customer of the energy supply organization, which is a separate legal entity of the cooperative.

three revenue streams: membership fees, margins on energy supply, and revenues from investors. An office annex shop was opened in the city centre of Groningen, where people can collect information and advice on the various activities of the cooperative.

Energy supply

In April 2012 a separate legal entity was erected for the cooperative, which acted as retailer of sustainable energy for both gas and electricity. A program director was appointed for the energy organisation, which was the first professional employee of the cooperative. While the Grunneger Power energy company did not owe a supply permit itself, energy supply was offered via the white label construction from Trianel (see Appendix 1). In their original business plan Grunneger Power planned to apply for a supply permit when they would have reached more than 5.000 customers. In December 2012, after the bankruptcy of Trianel, Grunneger Power chose to become a reseller, and offered their customers an intermediate solution to switch to SEPA Green as retailer. In the mean time they started the initiative to organise energy supply themselves, in cooperation with a number of other cooperatives in the three provinces in the northern Netherlands. This resulted in the establishment of three provincial cooperatives, each representing the local cooperatives of the three engaged provinces: Fryske Enerzjy Koöperaasje for Friesland, De Drentse KEI for Drenthe, and Groninger Energie Koepel (GrEK) for Groningen. In 2013 these three cooperatives in turn established an umbrella cooperative called NLD Energie (Northern Local Sustainable Energy). This cooperative of cooperatives applied for a supply permit, which was granted in early 2014. As of April 2014 NLD Energie started to supply sustainable energy (both electricity and gas) to the customers of the member cooperatives. By the end of 2016, 62 local energy cooperatives purchased their energy from NLD Energie (Schwencke, 2016). The participating cooperatives thus operate as a reseller for NLD Energie. Each cooperative receives a yearly fee for each of its members that have a contract with NLD Energie. Because of the layered cooperative structure, each member of the local cooperatives has a (in)direct vote in how the revenues of NLD Energie will be divided and spend. Meanwhile, Grunneger Power transferred all of its energy supply activities to NLD Energie, including its staff members.

Activities carried out

The first project of Grunneger Power was to stimulate solar panel installations. They made a preselection of a number of PV-panel suppliers and local installation companies. Whenever members chose one of the preferred suppliers and installation companies, they received a purchase rebate, while the cooperative received a small mediation fee for every installed panel

package. The cooperative played the role of intermediate, taking away the burden for the individual member to go through the selection process himself. The goal of the first activities was to create *visible value*, with the idea in mind that *volume follows value*.

Grunneger Power has set a unique landmark by being the first in the Netherlands to provide solar panels for rented houses of social housing corporation Nijestee. More than 1.000 solar panels have been installed that were paid by the corporation, while the tenants had to pay a slightly higher rent, meanwhile benefiting from a lower energy bill. As a follow-up several more comparable projects were initiated and realised in other neighbourhoods. Next to the promotional activities, Grunneger Power also offers independent advice on solar panels, both for individual households, housing associations and companies. Energy savings is also a spearhead activity, which is implemented by performing energy scans of houses and giving advice on which set of measures can be taken.

Grunneger Power started projects with a number of neighbourhoods in the city of Groningen that want to make their neighbourhood greener and more sustainable. Plans were made to install solar panels at suitable locations, next to placing green vegetation on roof tops in neighbourhoods. Furthermore, the installation of solar boilers was promoted, in cooperation with amongst others the municipality of Groningen. Grunneger Power realised two projects with roof-based collective PV panels, based on the postal code rose regulation (see also Appendix 1). Individual members can invest in solar panels at a shared location, where a tax deduction on the panels' energy production as well as shared revenues from the cooperation are settled via the energy bill of those who invested in the solar panels. Grunneger Power also operates ten charging poles for electric vehicles that are connected to one of the collective solar panel projects.

Future plans

For 2017, the realisation of a large PV park (2.300 kWp) is planned, making use of the SDE+ regulation (see Appendix 1), next to establishing more roof-based collective PV panel projects and the extension of cooperation with social housing corporations. The opportunities for realising one or more wind mills are being investigated.

Deployed and projected energy services

Early 2013, a group of Grunneger Power members, living in the same neighbourhood (Thomsonstraat), joined phase II of the smart grid pilot project

Power Matching City[13]. In the first phase of the pilot project (2010-2012) 25 households received innovative new energy installations, including heat pumps and µCHPs. The households were connected via internet, while the PowerMatcher coordination mechanism was successfully tested to match supply and demand between the allocated households. In the second phase, starting early 2013, the pilot was extended by providing the households with a home energy management system. The web based system provided the participants insight in their energy behaviour, but it also provided the means to plan and schedule the operation of smart appliances (e.g. washing machine, dish washer). Furthermore, it was possible to remotely set and control the thermostat and tune the thermostat settings to various profile schedules (e.g. workday, weekend, holidays, away from home). Two different user profiles were tested, based on the preferences of the participants. The group of participants with the *money driven profile*, received forecasts of fluctuating electricity prices (24 hours in advance), while the people with the *green driven profile* received a 24 hour forecast of the availability of green electricity. The forecasts were used as incentives for the participants, so they could anticipate their energy behaviour to the preferred energy goals they had set for themselves. The pilot project was finalised in September 2014. The results of the pilot project are described in (Geelen, 2014).

The PowerMatching City pilot was developed by DNV GL in cooperation with ICT Automatisering and a number of research institutes[14].

Case study III - LochemEnergie

History

The Lochem municipality with 33.000 inhabitants covers a quite spacious rural area with twelve village kernels, where Lochem city is the largest place with almost 14.000 inhabitants. In total there are 14.000 households within the municipality. The LochemEnergie cooperative started in 2011 for the citizens and businesses in the city of Lochem and its eleven regional municipalities.

Formulated goals

By 2030 LochemEnergie aims to generate and deliver sustainable energy, originating from the region that covers the full demand of all of its members. Besides the sustainability targets, LochemEnergie seeks to reinforce the local

[13] See also paragraph 2.4, section on Smart coordination for a description of the PowerMatching City project.
[14] See also: http://powermatchingcity.nl/site/pagina.php?id=7

economy and wants to stimulate the social cohesion by investing revenues in social projects like a swimming pool[15] or local sports clubs. The ambition is that 60% of the 14.000 households within the Lochem region will become customer of the cooperative energy company (approx. 9.500 households).

Organisational form

LochemEnergie chose for the cooperative form, which is governed by a six member board. The board is supported by a team of so called kernel coordinators, each representing one of the regional municipalities of the city of Lochem. The members of the cooperative each pay a yearly fee of € 25,- that covers for the costs of the various activities of the volunteers. Next to having a say in the cooperative, membership also entitles people to free advice on the purchase or rental of solar panels and solar boilers. The cooperative runs a local energy shop in the former historical town hall, which is made available by the municipality. The citizens of Lochem can visit the shop for information and for advice on energy savings and sustainable energy products.

Energy supply

In the first period Trianel was the sustainable energy supplier. Since the bankruptcy of Trianel in December 2012, the customers of LochemEnergie were transferred to the retailer Eneco. LochemEnergie acts as a reseller of Eneco, where the locally generated energy is incorporated in the reseller contract. Customers with a LochemEnergie membership receive a yearly rebate (€ 75,-) on their energy bill from Eneco. LochemEnergie receives a premium from Eneco for every customer they bring in.

Activities carried out

The collective PV panel purchase project that LochemEnergie facilitated for its members proved to be very successful. In 2013 the roof of the town hall was covered with 200 solar panels. Members of LochemEnergie could rent these panels (5 panels for € 20,- per month), while the produced energy was deducted from their yearly energy consumption (net metering). Furthermore, a water power turbine was installed in a barrage in one of the local streams, and the historical mill in the city also produces energy for the cooperative.

LochemEnergie organised so called *house greenings* meetings, where people invited friends and neighbours to their home for discussion, information exchange and advice on all kinds of energy related subjects. These house

[15] LochemEnergie invested in solar collectors for the heating of the swimming water of the municipality swimming pool.

greenings demonstrated to provide a very low threshold to get people interested in the activities of the cooperative.
Until now, LochemEnergie realised four collective solar park projects: one on the rooftop of the city's town hall, two on the roof tops of businesses and one ground based solar park in an industrial zone. Another project focuses on solar panels on school buildings. These projects are partly financed by the province and the associated municipalities, under the condition that parents and relatives of the school's pupils pay for at least 25% of the total budget. At this moment 2 schools in the Lochem region participate. Various regulations were applied for these solar projects: SDE for the ground-bound solar parks, the postal code rose for the company roof top project, and the net metering regulation for the other projects (see also Appendix 1).
Furthermore, LochemEnergie cooperated with two local social housing corporations that wanted to install solar panels on their tenants' rooftops, but only when tenants would agree. The rent of the solar panels was settled with the rental bill of the housing corporation. The tenant's lower energy bill should compensate for the higher rent.
LochemEnergie cooperates with a group of regional construction and installation companies, who are united in a cooperative collective, called Opgewekt Lochem. They participate in the House Subscription project, where home owners can realise home improvement measurements without any investments. The costs of the improvements are covered by the savings on the energy bill. LochemEnergie wanted to stimulate electric transport and made four electric cars available for rent for their members, at € 5,- per daily period. As an extra service, a free shuttle service (electric car, including driver) was offered to members that have to do business at the municipal inquiries office.

Future plans

The possibilities of wind mills in the region are investigated in cooperation with three neighbouring local initiatives, under the strict condition of broad public support. Furthermore, there are plans to extend the power capacity of the water power turbine in the barrage, next to installing more turbines in other places. The Lochem district covers a large agricultural area with a large potential for biomass energy.

Deployed and projected energy services

LochemEnergie operated as a pilot location for the IN4energy project[16], which started to operate in 2014 and ended in June 2015. More than 160 households in Lochem participated in the project that were connected via an

[16] See also: https://www.lochemenergie.net/in4energy

intelligent network. All participants were provided with a home energy management system that gave them insight in their energy behaviour. Eighty three of the participants installed solar panels on their houses with a total installed power of 275 kWp. Four more communal buildings were covered with PV panels with in total 225 kWp. The intelligent energy management system took care of the exchange and matching of energy between the participants. Part of the project was to perform a stress test whether the local grid could withstand the peak load of simultaneously loading electric vehicles. The final results of the IN4energy project were not yet available, but it was reported that the pilot strongly contributed to the social cohesion amongst the participants, as a result of all the collective activities that were executed. Plans are made to continue and probably extend the pilot.

There were a number of project partners involved. The University of Twente developed the technical concept of the smart grid pilot project, as well a number of simulation models. These models were field tested in this pilot project. MPARE brought in the home energy management system. The technology companies Eaton and Locamation developed the smart sensor hardware and software components that are used for measurement, control and security purposes. Alliander was the network operator, while Eneco was involved as retailer.

Case study IV - Zeenergie

History

The municipality of Zeewolde, situated in the province of Flevoland that was impoldered in the Sixties, is the youngest Dutch municipality started in 1984. The city of Zeewolde is the main residential area of the municipality with the majority of the total of 21.500 inhabitants (8.100 households). The Zeenergie cooperative was established in 2010 and is open for members who have an economic or societal binding with the municipality of Zeewolde[17].

Formulated goals

The goal of Zeenergie is to provide sustainable energy for its members at a low price. Besides the purchase of sustainable energy the cooperative also invests in local energy projects for own production capacity. The growth target is projected at 5.000 members, which includes both private households and businesses (e.g. shops, offices, companies).

[17] Zeenergie is the least elaborated case study. During the case study there were problems within the Zeenergie community in relation to the INZET project, which caused delay in the deployments of activities.

Organisational form
Members can buy shares for € 50,- each, and as such they get a vote in the cooperative meetings. The members of the cooperative receive rebate vouchers for sustainable products that are offered by local companies.

Energy supply
The cooperative act as reseller for the energy retailer Greenchoice.

Activities carried out
Zeenergie organised the '100 roof tops' project, a collective PV panel purchase operation, with the aim to install PV panels at a minimum of 100 roofs of individual households, companies or public buildings. In cooperation with six other energy cooperatives, Zeenergie invested in a windmill with a capacity of 850 kW. The generated electricity is supplied to the members of the cooperatives.

Future plans
Within the municipality of Zeewolde, which covers a large rural area, there are 225 wind mills and 7 bio digester installations located. It is the first Dutch municipality that has within its borders more sustainable production capacity than its yearly total energy demand. Plans are being made to bundle the sustainable generation capacity and make it available in a smart and efficient way for the Zeenergie community of Zeewolde.

Deployed and projected energy services
The Intelligent Network Zeewolde and Energy Transition (INZET) project aims to connect 4.000 households and 500 companies in the municipality of Zeewolde to an intelligent energy management system. The system informs and advices people on their energy usage and matches demand and supply of locally generated energy. The participants in the project will be equipped with controllable appliances in order to monitor and control energy in a smart way, while taking into account the participants' preferences. The project was originally planned to start in 2012, but for a number of reasons it has been delayed until September 2014 when a restart was announced.

Various partners participate in the INZET project. Zeenergie is the local energy cooperative. The municipality of Zeewolde and the province of Flevoland participate because they want to promote and support the sustainability goals that they have set for the year 2020. Sternweg operates a park of nine wind mills that supplies local sustainable energy. Van der Knaap dairy farming operates a biomass fuelled CHP installation that can be used as backup electricity supplier whenever the other sustainable production falls behind

actual demand. Alliander is the network operator, while ProXenergy is the company that will provide the smart energy management technology. The Delft University of Technology supervises the project and analyses the overall energy consumption and the required energy capacity.

Resume of the case studies

The exploratory case studies give us insight into the history of the prosumer communities and the activities they performed so far, as well as which activities are projected for further development. Summarising, we can make the following observations:

- All initiatives are initiated by citizens, with the aim to provide locally produced sustainable energy for their members. Reinforcing the local economy and stimulating social cohesion are considered to be at least as important. Local authorities played and still play an important role as both stimulator and facilitator, and in some cases as partner and customer of the initiatives. In the case of TexelEnergie the role of the municipality is less explicit.
- All initiatives have adopted the legal form of cooperative with limited liability.
- Local presence, having a local brand, and being recognisable in combination with the sustainability goals, are the main subjects that are being used for promotional activities and for member recruitment. As part of this strategy, three of the initiatives opened a local energy shop.
- Organising and offering sustainable energy supply in some form, as part of a service portfolio offered to potential customers, is seen as an important means to persuade people to join the initiative. The energy supply activities are organised within a separate legal entity, or these activities are outsourced to a third party (i.e. umbrella cooperative or green retailer). Furthermore, the energy supply activities generate an important revenue stream that can be used for investments in collective local sustainable energy generation.
- In three of the case studies, prosumer communities expressed their willingness to share knowledge and expertise with other initiatives, in order to prevent that each initiative has to reinvent the wheel. The willingness to share fits in with the principles of the International Co-operative Alliance (see also Section 1.2 on Changes in society).
- The participation in a smart grid pilot project is experimental and the first experiences have been collected and evaluated (Geelen, 2014). The results show that when participants are provided with feedback

(e.g. real-time energy consumption, energy price, availability of locally generated renewable energy) they gain insight in their energy behaviour (e.g. energy consumption) and the consequences of their behaviour (e.g. costs, CO2 emissions). The evaluation also showed that gained insight motivates people to adapt their behaviour, which eventually could lead to changing behaviour (e.g. shifting energy usage to other moments) and energy savings (TexelEnergie savings: 7% on electricity and 14% on gas). People also indicated that it was just fun to participate.

Besides the above mentioned observations, the case studies also learned us that prosumer communities ran into various problems and complexities that needed to be solved, and where strategic choices and decisions had to be made:

- *Stepwise development of growth path:* the pace of development of the prosumer communities growth path is largely dictated by the availability of the right people and resources. People are needed for staffing the working groups, the right expertise must be available to develop plans and negotiate with third parties, and financial resources must be unlocked to realise energy projects. New activities are started only when the necessary resources are available.
- *Member recruitment:* reaching the broad(er) public and convincing them to join the prosumer community initiative is not an easy job. Recruiting the innovators and the early adopters is fairly easy, while reaching and convincing the early majority was considered far more difficult, not to mention how to reach the late majority and the laggards. All cases considered this as a large challenge, although for TexelEnergie this seemed to be less of an issue.
- *Complexity of the energy business*: organising energy supply and realising large-scale energy projects is complex, where a wide variety of knowledge and expertise from various disciplines is needed, which is not always available within the community. The studied cases indicated that sharing knowledge and experiences amongst prosumer communities is important in order to prevent reinventing the wheel over and over again. Outsourcing activities to commercial parties or appointing paid professionals within the community's organisation sometimes conflicts with the local focus and the broad voluntary basis of the initiatives.
- *Scale versus locality*: energy supply under full control of a prosumer community (i.e. owing a supply permit) is only viable with a minimal number of customers. The prosumer communities have chosen an

intermediate solution by outsourcing energy supply to *green* retailers or by bundling forces with other initiatives and setting-up an joint umbrella cooperative, thus reaching the necessary scale. Scale is also an issue for obtaining and securing financial resources.

- *Obstructive legislation*: local initiatives are confronted with complex and inconsistent legislation, and uncertainties on the long-term availability of financial resources (e.g. the net metering regulation is only guaranteed until 2020). Making a viable business case for projected large-scale energy projects is therefore problematic.
- *Availability of smart grid technology and services*: the smart grid pilot projects, where the prosumer community cases participated in, showed positive results. Participants gained insight in their energy habits and behaviour, thus creating awareness and realising energy savings. Community awareness and social cohesion was also strengthened. Due to the temporally character of the pilot projects, the long term availability and support of smart energy services for the communities is uncertain.

Table 8 below shows a schematic resume of the four described case studies.

Table 8: Resume of the exploratory case studies

Case studies	**Texel Energie**	**Grunneger Power**	**Lochem Energie**	**Zeenergie**
Founded	2007	2011	2011	2010
Organisational form	Cooperative U.A.[18]	Cooperative U.A.	Cooperative U.A.	Cooperative U.A.
Members	3.200[19]	1.005[20]	600[21]	85[20]
Energy supply	Reseller of cooperative	Reseller of cooperative	Reseller of retailer	Reseller of retailer
Customers	4.000[19]	750[20]	300[21]	80[20]
Advice activities				
- Energy scans	V	V	V	-
- Housing insulation	V	V	V	-
- PV purchase	V	V	V	V
- Various	- *LED lights*	- *Neighbour-hood projects*	- *LED lights* - *House greenings*	-

[18] U.A. means limited liability.
[19] Source: http://www.texelenergie.nl. Last accessed 8 March 2015.
[20] Source: http://www.hieropgewekt.nl. Last accessed 6 May 2016.
[21] Source: http://www.lochemenergie.net. Last accessed 6 May 2016.

Case studies	Texel Energie	Grunneger Power	Lochem Energie	Zeenergie
Collective purchase projects	- *PV panels*	- *PV panels (including for housing corporations)* - *EV load stations*	- *PV panels - including for housing corporations*	- *PV panels*
PV lease	V	-	-	-
Energy projects				
- PV park	4 realised	3 realised	6 realised	Planned
- Wind mill(s)	Explored	Explored	Explored	V
- Biomass (electricity/ gas)	n.a.	n.a.	Explored	V
- Biomass (heat)	Heat stove	Explored	Explored	Optional
- Hydro	n.a.	n.a.	V	n.a.
- Tidal	Explored	n.a.	n.a.	n.a.
- Geothermal	Explored	Optional	Optional	Optional
- Various	- *Heat storage explored* - *Electric cars*	- *Solar boilers*	- *Solar boilers* - *Electric cars*	
Energy Services				
Pilot project	CloudPower	PowerMatching City II	IN4energy	INZET
Status	Finished	Finished	Finished	Ongoing
Services involved	- *Energy monitoring* - *Savings advice* - *Price forecasting* - *Appliance monitoring*	- *Energy monitoring* - *Price & sustainable energy forecast* - *Smart appliances* - *Appliance monitoring* - *Smart matching* - *Community monitoring*	- *Energy monitoring* - *Savings advice* - *Smart EV loading* - *Smart matching*	- *Smart matching* - *Storage*

3.3 Group sessions

Prosumer communities exist merely by the grace of their members. Therefore we want to discover how individual participants value the development of prosumer communities, what is important for them, and how they see their role as participant. For that purpose we carried out two group sessions with residents from the Thomsonstraat in Groningen. They were involved in a neighbourhood initiative, where they wanted to explore to what extent their neighbourhood could become energy neutral or even fully self-supportive, and how this could be realised[22]. Previously, an engineering firm worked out a number of scenarios, describing a number of possible technical solutions for the neighbourhood.

The Thomsonstraat residents were a very active group, which perfectly fitted in the profile of active prosumer community participants. At that very moment there was a discussion on the collective purchase of PV panels for the neighbourhood. The researcher offered to facilitate this discussion with a Group Support System. Although this topic of discussion was not the primary goal of the research, it was interesting to get better insight in drivers and motivations of individual participants. The first session was a useful leg up to the second session, which fully focussed on the subject of research. The two sessions worked both ways: facilitating the residents' discussions and providing input for the research project.

Subjects of the group sessions

The first group session focussed on the question whether there was support for a collective solar panel purchase action, and which preconditions participants would pose on installing solar panels in their neighbourhood. In the second group session the question was what participants, as members of a prosumer community, thought they would need qua information and tools to monitor and control their energy streams within their homes and within the community.

Group Support System

We used a Group Support System (GSS) to facilitate and structure the collaborative activity of the group sessions. Research and field experiences "have provided evidence that the use of a Group Support System can improve the efficiency and effectiveness of collaboration in organisations" (Kolfschoten & Vreede, 2009). The GSS was used in both sessions to collect the arguments

[22] The Thomsonstraat initiative later on joined the Grunneger Power cooperative. In 2013 fifteen households also participated in phase II of the PowerMatching City smart grid pilot project (see paragraph 2.4, section on Smart coordination).

and opinions of the participants. Subsequently, the discussion process was structured in such a way that at the end of the sessions the participants would have a common understanding of the subject at hand, without necessarily reaching consensus.

Location and organisation of the group sessions

Both group sessions were carried out in a community building close to the Thomsonstraat, the first session in April 2011 and the second in June 2011. We used a mobile version of the GSS system[23], where the participants could work with a laptop that was connected to a central GSS server unit. The session was conducted by a facilitator, while an assistant operated the central session control (i.e. the GSS server unit). The researcher observed the sessions and, when necessary, he could intervene.

Pilot sessions

Prior to the two Thomsonstraat sessions, two pilot sessions were executed with students and employees of the Hanze University of Applied Sciences Groningen, in order to test the content and structure of the session, and whether it would yield valuable results. Based on the outcomes of the pilot sessions some minor changes were made. The pilot sessions took place at the FEB Research Lab at the premises of the University of Groningen.

thinkLets building blocks

The thinkLets building block methodology (Briggs & De Vreede, 2009) was adopted to structure the group sessions (see sessions' transcripts in Timmerman, 2015). A thinkLet describes all relevant information to create a pattern of collaboration in a group of people, working together towards a common goal (Kolfschoten & Vreede, 2009). A thinkLet can be applied in a group session to produce more predictable and repeatable results while generating ideas. Briggs et al. (2003) distinguish six different collaboration patterns or basic group process activities:

1. *Generate*, where the group has to create new concepts that have not been considered before (diverge). Brainstorming is an example of a generation pattern.
2. *Reduce*, where the group has the task to reduce the number of concepts (filtering, abstracting).
3. *Clarify*, is used to build shared understanding on context and possible actions, which is needed to meet the group's objective.

[23] ThinkTank GroupSystems Corporation©.

4. *Organise*, is used to identify relationships between the various concepts. Labelling arguments and categorise them into a number of groups is an example of this collaboration pattern.
5. *Evaluate*, is applied to focus a group's discussion, where the participants express their preferences, and discuss and negotiate to determine the best choices. Voting is an example of an evaluation collaboration pattern.
6. *Consensus building*, is used to move the group from less agreement to more agreement, in order to create commitment.

Each thinkLet correspondents with a specific functional component in the GSS. It defines how to use the component and how to configure it. By combining thinkLets in a specific order, based on the tasks and activities that have to be performed, the agenda of a group session is built up. Figure 7 shows the agenda, as an example of a Facilitation Process Model, of the second group session, that is based on various thinkLets. Each block in Figure 7 shows a sequence number (e.g. 6), the thinkLet name (e.g. PopcornSort), the starting time (e.g. 20:15), the pattern of collaboration (e.g. Organise), and the activity that needs to be performed (e.g. Make categories and move arguments into categories).

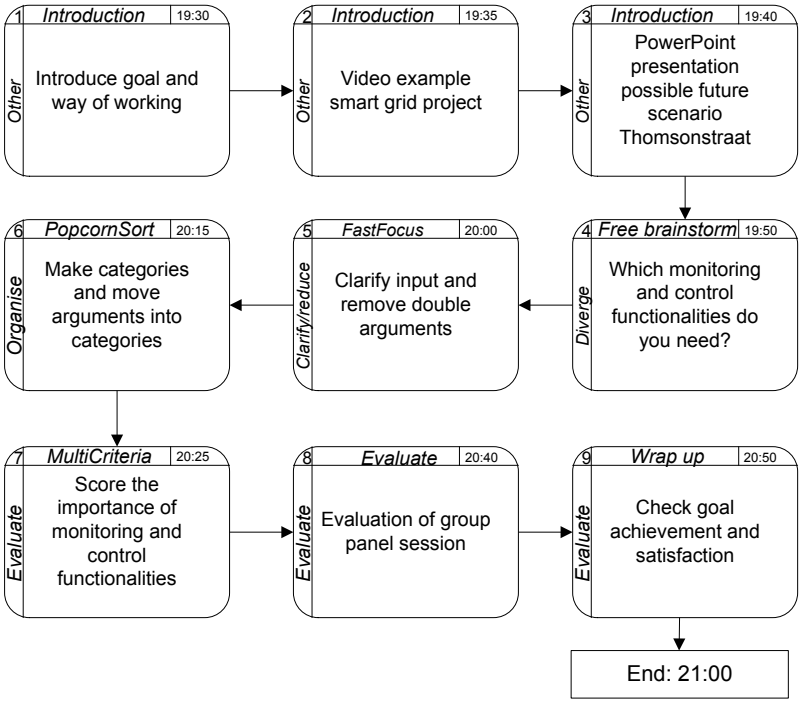


Figure 7: ThinkLets agenda of the second group session

Group session I - PV panels in the neighbourhood

The first session was used for information exchange and discussion on collective purchase of PV panels for the Thomsonstraat. It was part of a general meeting of the neighbourhood committee, where the collective PV panel purchase was the main subject on the agenda. 12 residents participated. The session provided valuable information on the process of decision making within a small neighbourhood community, as well as insight in opinions and motivations of participants.

The session started with showing an artist's impression of possible PV panel installations at various possible locations in the neighbourhood. The twelve participants were asked what would be their main considerations and prerequisites for purchasing PV panels. When their arguments were collected, discussed and reorganised, they were invited to select and prioritise the five most important considerations. The arguments that came forward with the highest overall score, were:

- Energy conservation (7 out of 12);
- Contribution to a sustainable society (5 out of 12);
- Profitable investment (4 out of 12);
- Free or cheap energy (3 out of 12);
- Independency from energy companies (3 out of 12);
- Generating energy yourself is fun! (3 out 12).

Besides the considerations in favour of purchasing PV panels, also a number of opposite arguments were brought forward:

- Esthetical problems with visible PV panels on roof tops in the neighbourhood (7 out of 12);
- PV panels should be placed outside the neighbourhood (3 out of 12);
- High cost, low profits (3 out of 12).

In the next round of the session it was investigated where people would want to install PV panels on their premises (roof top and/or garage and/or pergola), and if the installed panels should be for collective or for individual use. Not all questions were applicable for all participants, so they could also indicate 'n/a' or 'no opinion'. The opinions were equally divided over supporters for and opponents against collective use of the panels.
At the beginning of the session the participants were asked by hand raising whether they would be interested in purchasing solar panels. Nine out of twelve participants were positive. At the end of the session the similar question was raised via GSS. The respondents could indicate whether they

would be interested to purchase PV panels individually, collectively, or no interest. Ten respondents were positive on purchasing PV panels (3 individually, 7 collectively), while two respondents indicated to have no interest. Because the GSS voting was anonymous it was not possible to retrieve which respondents voted the same or differently.
In the session evaluation the participants were unanimously positive on the added value of the GSS for speeding up and improving the quality of the decision process. They were also positive on the contribution of the GSS system for forming their opinion on PV panels in their neighbourhood. The GSS transcript of the session, its results and the results analysis are described in a separate report (Timmerman, 2015).

Group session II –Energy control

The goal of the second Thomsonstraat session was to explore what the participants, as members of a prosumer community, thought they would need qua information and tools to monitor and control their energy streams within their homes and within the community. Eighteen residents participated. The session agenda is depicted in Figure 7.

The session started with presenting a possible future scenario of a smart grid enabled community by showing a short movie of the Power Matching City smart grid pilot project[24]. A PowerPoint slide presentation then illustrated a possible scenario implementation for the Thomsonstraat. It showed a number of households equipped with generation facilities (PV panels, micro-CHPs) and a number of smart controllable appliances (washing machine, dish washer, heat pump). An electric car could be used for storage. The houses were part of a local prosumer community, where supply and demand was exchanged at a local marketplace based on flexible pricing and availability of sustainable energy.
After the presentation, the eighteen participants were asked what features they would need to control the energy flows in their own house and in the neighbourhood, as efficient and sustainable as possible. After the first round of idea generation the enlisted control features (46) were discussed plenary. Double arguments were deleted, while some arguments were clarified and edited after explanation. A list of 28 features remained, which were then labelled and categorised. In the next round the participants were asked to score each of the control features on importance, with a High (absolute

[24] For description of PowerMatching City project see paragraph 2.4 in section on Smart coordination.

necessary), Medium (desirable, not absolutely necessary) or Low (not important). The weight of the scores: High – 3 points; Medium – 2 points; Low – 1 point.

The top 10 score on required control features was:

1. Possibility to overrule the automated system (48 points);
2. Insight in my own energy consumption (47 points);
3. The system should not cause shortage of energy (47 points);
4. The system should be easy to use (usability) (46 points);
5. Self-control on heating (41 points);
6. Self-control on switch on/off of appliances (40 points);
7. Automatic control when switching on/off appliances is cheapest (40 points);
8. Control on price for buying/selling energy (38 points);
9. Overview of energy consumption of appliances and devices (38 points);
10. No self-control; I want to fully outsource control (36 points).

When analysing the above scores, we can draw the following conclusions with respect to the required features:

- They want to be in control (1, 5, 6 and 8);
- Insight in energy consumption (2 and 9) as well as usability (4) have a high priority;
- Security of supply (comfort) should be guaranteed (3).

There seems to be a contradiction between 6. Self-control of appliances, and 7. Automatic control. They have the same score, although the standard deviation of 6. is slightly lower[25].

In the session evaluation the participants indicated that they gained insight into the future possibilities of a smart grid enabled prosumer community. Fifteen out of seventeen[26] stated that they would want to participate in such a sketched scenario. Nine of the seventeen participants indicated that they would not be willing to outsource the means of control to a third party. Almost unanimously they concluded that the session was meaningful for the future decision process of the Thomsonstraat. The GSS transcript of the session, its results and the results analysis are described in a separate report (Timmerman, 2015).

[25] Because the session were anonymous, it was not possible to compare the scores of the individual participants. The apparent contradiction could be explained by the ambivalence between wanting to be in control and not wanting to put too much effort into it (i.e. wanting to be relieved).
[26] One vote was missing, due to technical problems.

Resume of the group sessions

The first session teaches us which drivers and motivations of (potential) participants play a role in participating and making decisions in a collective energy project, including sustainability arguments, and economic, aesthetic and social values. It relates to all three aspects of decisions enhancement people, process and technology. The second session provides us with insight what are the demands and needs of prosumer community participants with respect to tooling for energy control and energy management in their own premises and as part of a community. It shows which facilities/services are relevant for individual prosumer community participants that should be taken into account when designing a solution for prosumer community decision enhancement. It also teaches us that a GSS is helpful in facilitating decision enhancement in a prosumer community setting.

3.4 Stakeholder interviews

As part of the exploration phase, forty seven interviews have been conducted with people from different organisations that are in some way related to the prosumer communities' value network. The aim of the interviews was to provide supplementary information in addition to the case studies. It deepened our insight in the playing field where prosumer communities operate in, and explored current and potential issues with respect to the development of prosumer communities: who are the stakeholders, what is their specific role, how do they see the current and future role of prosumer communities in the energy sector, what are relevant developments and technologies. The interviews were open and semi-structured, with questions related to the topics mentioned above. The topic list (see Appendix 3) was used as an outline for the conversation. During the interviews the interviewees brought various other subjects to the table. The relevance of these topics for our research in the exploration phase is that it provides us insight in "issues that matter", which is the line of approach of exploration in design science research.

Interview participants

The people that were interviewed represent a number of actors that play a role in the prosumer communities' value network (see also Appendix 4):

- Grid operator: Enexis, Liander;
- Retailer: Oxxio, Essent, Greenchoice, GasTerra;
- A cluster organisation: Energy Valley;
- Research and consultancy: University of Groningen, University of Eindhoven, ECN, TNO, DNV GL, UCPartners;

- Authority: Agentschap.nl/RVO;
- Service providers: Netinium, Metsens, Eemflow, Qurrent, AllAboutEnergy, AurumEurope ;
- Prosumer communities: TexelEnergie, Grunneger Power, LochemEnergie, Amelander Energie Coöperatie, NoordenWind Coöperatie;
- Two individual households.

Processing of the interviews

During the interview notes were made, which later on were worked out in a concise report (Timmerman, 2015). When the interviews were analysed, a number of topics could be distracted that were brought forward multiple times. In the following sections we use these topics as headings for clustering the results of the interviews.

Interview results

The interview results are described here as a summary and compilation of all the topics that came to the table during the interviews. As is explained in the previous paragraph 'Processing of the interviews', the headings are derived from the topics that were brought forward multiple times by the various interviewees, and presumably they consider these topics to be relevant. The interview results are listed under the following headings:

- Telecom versus energy: a comparison of the developments in the telecom industry and the energy sector;
- Role of the authorities;
- Role of the grid operator;
- Role of the energy retailer;
- Role of the service provider;
- Prosumer communities;
- Individual prosumers.

Telecom versus energy

In several interviews the parallel between the developments in the telecom industry and the energy sector came forward. The main similarities that were mentioned were the enforced unbundling of the value chain, thus creating a competitive market place, the increased role of ICT in the physical network, and the increased freedom of choice for the customers. Nonetheless, also essential differences were mentioned. First of all the telecom market unbundling started 15 years earlier than the one in the energy sector. The second noted difference relates to the role of the supervisory authority. In the telecom sector the Dutch operator KPN used to hold a monopolistic market

position. The responsible supervisor operated from a strong political perspective and the unbundling process was economically driven. The Dutch energy market was already partly divided, with harsh competition from large international players (e.g. from Germany and France). In the unbundling process the energy supervisor acted much more technical, breaking up the value chain in different technical domains. Thirdly, it was noted that the energy grid operator still has a dominant position, even though the operational domain is strictly regulated. And as a fourth difference, the intrinsic value of the commodity was mentioned. Data traffic in telecommunication is essentially different from energy streams. As one of the interviewees noted: "It is not obvious how to translate the peer-to-peer telecommunication concept to the energy domain. There is no such thing as an OSI reference model for energy." Overall, there was agreement that the lessons learned from the transition process in the telecom domain are useful for and applicable to the energy transition process.

Role of the authorities[27]

One of the interviewees brought up the double role of the authorities: "On the one hand they are the rule issuing body, making the laws and setting the boundaries for the energy playing field. On the other hand they are an interested party with respect to revenues from energy taxes, which might be conflicting with setting sustainability targets that potentially cannibalise the tax revenue streams." Another interviewee remarked: "The authorities could be more imperative in forcing the energy companies to cooperate. Energy companies miss the intrinsic motivation to be transparent." He mentioned an example of the Australian government, who enforced the grid operators to collectively equip and operate a shared service centre that they otherwise probably would have developed separately.

Role of the grid operator

There was broad consensus that grid operators play an essential role, from different perspectives, in the transition process towards a sustainable energy system. Their main responsibility is to ensure a stable and future-proof physical infrastructure, and to safeguard the quality and security of supply. Security of supply means that energy must be available for every customer at any time. But fitting the grid to the maximum possible demand peak load would imply an over-dimensioning of the infrastructure, with huge investments of public money involved. Therefore, it was suggested that it would be more economical to invest in other mechanisms, like smart coordination of local sources and possibly storage facilities. As one of the

[27] Authorities in this context relate to the national governing body.

interviewees said: “Until now load follows demand. This will change to demand following the load.”

The increasing energy demand and the inclusion of intermittent renewable energy sources demand for a change in the energy control mechanism. As one of the respondents noted: “When sustainability is a political choice, automatically it will lead to distributed generation systems, claiming large surface areas, due to the relatively small capacity of the renewable resources. The necessity for smart grids is evident. Connection, control and matching is needed for balancing, where local use of local generated energy is the starting point. This way the central system will be unburdened.” Where one other interviewee added: “The responsibility of load management and control will partly shift from the transmission system operator (TSO) to the operator of the distribution grid (DSO). That is the network segment where increasingly more flexible and unpredictable loads will emerge.”

Unpredictable loads are partly caused by the renewable generation facilities, but also by the trend of electrification, which is a consequence of, amongst others, the increasing use of heat pumps and electric vehicles. On the other hand electrification also provides increasing flexibility which is needed for balancing, as one of the interviewees brought up: “Mobility is one of the drivers for smart grids. Electric transport provides, to a large extent, flexibility and availability. The majority of the cars are 20 to 22 hours a day available for loading and unloading, thus providing an enormous flexible buffering potential, much more than from household appliances such as washing machines and dish washers. Flexible buffers are essential in the combination with renewable generation, due to the unpredictable characteristics of these resources.”

The roll-out of smart meters is the task of grid operators. “Smart meters open up real-time online data that can serve as a basis for energy related information streams and value added services. That’s the place where new business is to be made, and new business models will emerge.” Demand response applications, load control, and local balancing of demand and supply are among the list of new services that were mentioned. According to the interviewees, the major change that will occur is the introduction of a control mechanism at the distribution level of the network. The respondents foresee a modular and layered control structure, with households at the basis, where appliances and generators are coupled. The households in turn will be linked to a control system on neighbourhood level, and so forth.

One of the respondents was rather fiercely on the number of pseudo-experts: “There are many people claiming to know which direction we should go, without necessarily being knowledgeable on the subject. Many people think in terms of capacity instead of power, which is a fundamental difference!”

Should service development and deployment be left to the free market? And should regulated parties like grid operators be excluded? “No, not by definition,” as one of the respondents said: “Grid operators are very knowledgeable on the complexity of the energy system. It would not be such a bad idea to deliver some essential services that come along with the smart meter as a standard option, and socialise the cost with the energy bill. Leaving it to commercial parties will not always deliver the right and best solutions.”

“The basis for the energy transition should be a solid analysis of the value chain. What is the added value of each of the roles in the value chain, and where is that value based on? Economic arguments should be leading in restructuring the value chain, and developing new business models.”

What about autarkic regions, or fully self-supportive micro-grids? “There will always be a role for the central grid and a connection to the distribution grid will still be needed. A fully autarkic system at a local level is not realistic, while you need to cover up for failures and breakdowns. The central grid functions as a back-up facility.” One of the interviewed researchers noted: “It’s questionable whether autarkic energy units (i.e. micro grids) will be economically feasible. Being fully self-supportive is probably only feasible in rural areas, where there is a mix of complementary resources available (e.g. wind, solar, biomass). Using local generated energy at a local level is not by definition the most cost-effective solution. It’s about the marginal costs. In some cases, when for instance there is a surplus from a large off-shore wind mill park, it can be more efficient and economical to use that energy, instead of using your neighbour’s energy. Such kind of assessments have to be built into the new energy system.”

One of the respondents questioned where the intelligence in the energy value chain should reside: “Smart-anything is very popular, but things like smart homes, in spite of high promises, never took off due to high costs and the complexity for the average user. And why put the intelligence in the network, while appliances like a μCHPs and heat pumps can decide themselves when it is the best moment to operate, based on network status information? The same goes for electric vehicles.”

The respondents were univocal on the importance of smart grid developments, although drawbacks are involved: “Smart grids introduce an important role for the telecommunication provider. The communication infrastructure, on top of the physical energy network, then is on the critical path of the system, although intrinsically it is not part of the primary process (i.e. transport of energy). A breakdown of the communication system potentially jeopardises the supply of energy.”

Role of the energy retailer

In our interviews it became apparent that the energy transition has a major impact on the role of the energy retailers. As one of the interviewed retailers said: “In due time the role of the retailer will change from supplier of energy, as a commodity, to provider of value added services. We need to work out new business models for that.” The introduction of the smart meter is seen as enabler, while it opens up the potential for many new value added services. Examples of such services that were mentioned include advice on energy usage, sending alerts when appliances start using too much energy, and pay-per-use services in combination with leasing appliances. As one of the retailers said: “Providing value added services in itself is business, but it also contributes to customer retention.” The business case is the main incentive for the energy retailer. One of the interviewees said that giving customers advice on energy savings is in principal a one-time business. Even worse, it will cannibalise the retailer’s turnover and margins.

Service offerings to individual consumers is regarded interesting, but even more clusters of consumers like prosumer communities or housing corporates are seen as target groups. “We, as energy retailers, are experienced in handling large, complex administrative processes. We can serve the prosumer communities by offering our expertise.”

For constructing the daily forecasts for their trading portfolio, retailers use different consumer typologies. But this will change, as one of the respondents brought up: “When distributed generation will be realised at a large-scale, the demand and production patterns of consumers will be harder to predict. Consequently, making trustworthy trade forecasts will become much more complex.”

“It might be interesting to explore the role of the nomadic energy retailer. The nomadic retailer is not restricted to one physical connection point (e.g. a household connection). The customer will take his retailer with him where ever he is going to use energy (e.g. for loading his electric vehicle).”

The role of service providers

One of the issues that came up in the interviews was the question which parties are going to develop and exploit the new value added services: the incumbent energy companies, or businesses that will come from outside the energy sector? Here are some quotes.

"The energy transition process, including the emergence of prosumer communities, provides opportunities for developing and offering new services. Incumbent energy companies represent the vested interests, but these are not necessarily in line with the interests of the consumers. Potentially there is a role for the energy companies to develop new services: they have market dominance and the financial power, but innovation power is not necessarily their natural quality. This offers business opportunities for other parties to move into the energy market place."

"People are willing to invest in tools that will save them money on their energy budget, when they have the idea that the investments will pay back within reasonable time. They will only be willingly to outsource their energy management to a third party, whenever there is trust and control. When these conditions are met, then services like remote switching of appliances for demand response will be adopted. "

"The service providers have to create a local energy market place, where locally generated energy can be traded. A connection to the external market place should be included, in order to include other non-local sustainable resources. Freedom of choice is an important issue for the end-user, next to being in control. Furthermore, the services being offered should be customer-tailored and easy to use. A good user interface is essential."

There was agreement that the introduction of the smart meter is an important stepping stone for the development of new services. But some interviewees see the smart meter as "a data generator", while a separate service gateway is seen as the basis for service provisioning to the end-users: "The one who owns the home service gateway, will cash in."

Standardisation is considered as one of the key issues for the success or failure of service development. The large-scale introduction of distributed generation, along with connecting household appliances as active components to the energy system, introduces an enormous amount of communication nodes that have to be controlled and managed. "If they do not speak the same language, then we will create an inefficient system with Babel-like confusion of tongues." Systems should therefore be based on open

standards, with scalability as an important prerequisite. Middleware platforms, using web services, XML and SOA, were mentioned as being applicable technologies, as well as multi-agent technologies and Internet-of-Things, or its analogy Internet-of-Energy.

Prosumer communities

"Collectivism creates power," as one of the interviewees stated firmly. He continued: "As an individual it is very hard to play a significant role in the complex energy world. Working together creates opportunities on both the technical and financial level, which otherwise would be out of reach for the individual. Furthermore, the social cohesion aspect is interesting in times of individualism."

A project manager from the ministry of Economic affairs, who coordinates and advices local energy initiatives, remarked: "Characteristic for the local bottom-up initiatives is the enthusiasm and the high level of involvement and commitment. But there is also a lot of amateurism, due to lack of the right expertise. The most successful initiatives have the right experts on board, next to determined people that carry the load. Successful initiatives have shown to choose for a broad scheme and an integral approach." As an illustration of a successful initiative, he mentioned the example of a communal wind mill project, which was combined with a project for collective energy savings and a project on how energy can be mutually exchanged. Foremost, a good organisational structure was considered to be the most critical success factor.

It was noted that, when starting up a prosumer community, it is essential to get the right people aboard with the right expertise. "Sharing of expertise amongst initiatives is important, while we want to learn from each other and we don't want to make the same mistakes over and over again." In this context, one notified: "Not only locally, but also at a national level there is the emerging phenomena of umbrella cooperatives, who cluster knowledge and expertise for sharing with the smaller cooperative units." Another important function of the umbrella cooperatives that came up was the bargaining power they provide for both collective purchasing programs, but even more importantly also for lobbying at authorities for adjustment of obstructive legislation.

One prosumer community representative, on the added value of prosumer communities: "[…] is their local presence: they are recognisable, and people can identify themselves with the initiative. It is personal (e.g. no distant call centre) with a low threshold, and the community represents a local economic and social value." As another interviewee brought forward: "Local initiatives

do not have an expensive management staff with company cars and fat bonuses, and distant shareholders that want to receive dividends.“ Another quoted: “Local initiatives have the role to make people think and activate them, as a countermovement against the large-scale oriented energy businesses.”

“In one of our pilots we experimented with an energy management system that provided feedback to the participating households. An interesting thing what happened, which we did not foresee, was that the participants started to use the online forum to help solve each other’s problems that they encountered with the system. I call that a spontaneous co-creation process of *customer-helps-customer*.”

The regional environment and circumstances determine the possibilities for sustainable energy generation exploitation. One of the representative of an urban initiative noted: “For initiatives in an urban environment it is important to connect to the surrounding rural area. Not only for opening up the potential of available resources for sustainable energy generation, but also for emotional reasons.” One representative of a windmill cooperative, active since 1986, stated: “Our key to success is *the participation principle*. Our members feel connected to the wind mills, because they are co-owner. Many wind mill projects are facing a lot of resistance, because the neighbouring people are not involved in the development process, or only in a late stage.”

And how about the economic viability of prosumer communities? One interviewee made the following observation: “The energy value chain includes a number of touch points with considerable margins. Between production and trade there is a margin of 15-20%, while between trade and supply there is a margin of 12-15%. With five thousand customers or more it is economically opportune for prosumer communities to apply for a supply permit, and jump into the latter part of the value chain.”

A number of barriers that were encountered by prosumer communities came forward in the interviews like obstructive legislation and access to financial resources.

Individual prosumers

Various respondents notified that the development of smart grids is strongly driven by the interests of the energy companies, with a focus on operational efficiency and savings on operational costs. There is no customer orientation. End-users are hardly involved, while they play an important role as buyers and consumers of the energy, and as such determine the volume needed. One

interviewee had a pronounced vision: “Ultimately the end-user should be provided with optimal freedom of choice what to do with his energy, and when. When I am on holidays, I want to donate the energy of my solar panels to my granddaughter, who is a poor student.”

The introduction of the smart meter enables consumers to receive direct feedback on their energy usage, as one respondent brought forward: “User feedback on energy usage is useful for creating awareness and influencing energy behaviour. I always make the comparison with the feedback I get from my car display that shows me how economically I am driving. That’s really influencing my driving habits.” On the other hand, there is resistance against the smart meter, while people doubt about the guarantee of privacy and security: is Big Brother watching you?

Household appliances, equipped with a communication module, will become part of the smart energy grid and can be involved in locally balancing demand and supply. One respondent noted: “It cannot be expected that the grid operator or the retailer will directly control the household appliances, while this will not be accepted. Instead, incentives will be generated (e.g. price, availability of sustainable energy) that should encourage consumers to adapt their energy usage pattern.”

Many of the interviewees brought forward that the current role of the end-users will change in the future. When he starts producing his own energy, he will become an active participant on the energy market. It is questionable whether the individual prosumer himself will act as a trader on the energy market. More likely, this will be facilitated by a service provider who will act as an aggregator and intermediate for both individuals and groups of prosumers. Service providers should optimally relief the end-user by offering all kinds of services, because end-users do not want to be bothered with too much complexity. There is one but in the matter, as one respondent mentioned: “The consumer still wants to sit at the controls. Control and trust are key issues.”

“Earning money is not my motivation. Sustainability has the greatest weight,” as one of the interviewees stated. She indicated that eventually, in the long term, the investment costs should be recovered. Investing in collective facilities was also an option for her, although she laid down one condition: “It should not happen, when I am doing my best to cut back my power consumption, while someone else stokes up the fire with the doors and windows wide open. Using collective facilities should be accompanied with rules of conduct.” Later on in the interview she reflected on using demand

response type of services: “It’s no problem for me when the dish washer runs a few hours later, but I do want to know what are the motives for doing so and for whom. I would like to be informed on that.”

Another respondent indicated that economic benefits would play a role in her decision to participate in a collective energy project, although marginal to nil revenues would be acceptable. “I would like to receive real-time information on my energy consumption, and what share my various household appliances are taking. I am not only sensitive to economic incentives (e.g. savings), but also to emotional feedback. Feedback should be related to earlier choices I’ve made, such as the purchase of solar panels, or scheduling the operation of the washing machine.” To the respondent’s opinion the grid operator could play a role in providing storage facilities in the neighbourhood.

Resume of the stakeholder interviews

A variety of subjects was brought to the table in the stakeholder interviews, which gave us a broad perspective on the emergence of prosumer communities in the context of developments in the energy domain. The double role of the authorities was mentioned as messenger and stimulator of sustainability activities on the one hand, and collector of energy taxes on the other hand. Grid operators play a pivotal role in the upgrade of the infrastructure towards a future proof smart grid, with an increasing role for the distribution grid operator in load balancing, due to the high impact of the integration of renewable resources. ICT and standardisation were regarded as sine qua non. The role of retailers will gradually shift from energy supplier towards supplier of value added services. And that is where the service providers come in, possibly coming from outside the traditional energy value network, because these parties presumably have more innovation power than the traditional energy incumbents. The interviewees confirmed the results of the case studies, addressing the critical issues for success of prosumer communities, such as availability of the right expertise, next to organisational power and the value of knowledge sharing. The role of prosumer communities was considered key for mobilising people at the local level for the sustainability cause. This conclusion is underpinned by Forrest & Wiek (2014), who state that “community initiatives have the ability to engage and empower local people in a way that top-down efforts often fail”. The local initiatives are recognisable and trusted, representing a social and economic value. The role of end-users, as participative prosumers, was also recognised as being important, while at the same time it was noted that they are hardly involved in the development process of the future energy system. This pleads for a co-creation role of the end-users in the development process.

3.5 Summary

In this chapter we described the exploratory study as part of the inductive-hypothetic research strategy, consisting of four real-life prosumer community case studies, next to two group sessions with prosumer community participants and interviews with various actors from the prosumer communities' value network. The exploration provided indicative empirical evidence on the issues related to the emergence of prosumer communities. The case studies gave us insight in the prosumer communities' growth path as we explored how they are organised, which activities they have performed so far, next to their future plans. It also sheds a light on the problems and complexities that were encountered along the pathway from starting up a local initiative up to where they are now. In the group sessions the participants expressed their considerations for purchasing solar panels in their neighbourhood, and which features they would like to have when participating in a smart grid enabled prosumer community. Trust, control and usability were mentioned as key conditions for using automated tools. The interviews gave us a broad reflection on how the various stakeholders view the developments in the energy sector, and which role they foresee for prosumer communities.

In the next chapter we will further analyse the results of the exploratory study in order to abstract a generic understanding of the real design issues that need to be resolved.

4 Generic understanding of the growth path of prosumer communities

In this chapter we further analyse the findings of the exploratory study with the purpose to get better insight in the growth path of prosumer communities. From the case studies we abstract a generic understanding of the prosumer communities' growth path, considering the activities performed along with encountered problems, amplifying which decisions were involved, and what was needed to make these decisions. Furthermore, we identify the various phases of the growth path. Finally, we identify the generic requirements that have to be satisfied by a solution for enhancing the decision making process of prosumer communities.

4.1 Case study analysis

For the analysis of the case studies we use the *analytical-evaluative framework* of Forrest & Wiek (2014). The Forrest & Wiek analysis framework stands in a long time tradition of design science research as one of the tools to make the step from exploration to understanding. Their framework is based on the empirical research approach of amongst others Ostrom (2009), which fits in with the design science approach that goes back to the 1980's. The framework for evaluating and analysing local energy initiatives is particularly interesting and useful for our research because they follow a stepwise approach to analyse the followed transition path (in our case: growth path), which outcomes were delivered (in our case: performed activities and their results), and what was the added value of each outcome, aiming at identifying critical success factors and producing practical guidelines. This very much aligns with our research, although our focus is not on success factors but more specifically on the barriers for success and what is needed to solve these problems (i.e. decision enhancement), while we also want to provide practical guidelines. Due to the different focus, we therefore slightly adapted the framework, which aligns with the statement of Forrest & Wieck (ibid) that "it is not a prescriptive, off-the-shelf tool: within the steps and analytical schema there is considerable latitude for variation and utilizing diverse methods, allowing other researchers to take a similar approach to other cases."

In our case study analysis we go through the following five steps:

- **Step 1: identify activities and outputs**
  The first step of the analysis is to identify which activities have been deployed within the case studies. For each activity a short description is given as well as the delivered outputs of the activity.
- **Step 2: reconstruct the sequence of events**
  In this step we identify the sequence of events from the start of an activity to the outputs that are delivered. Furthermore, we point out the bottlenecks and problems that were encountered. By reconstructing the sequence of events we get insight in the growth path of prosumer communities.
- **Step 3: analyse the outcomes**
  By analysing the outcomes of each of the activities we identify the immediate impact of the activities on the community (e.g. obtained energy savings or created work).
- **Step 4: identify decisions**
  In step 4 we want to identify the decisions that were involved in each of the activities and related events. For each decision we then explore what was needed for making that decision.
- **Step 5: identify who were involved**
  Finally, in step 5 we identify the various stakeholders that were involved in the activities and the related decision processes, and what was their role. This gives us an overview of the prosumer communities value network.

Each of the five steps is described in more detail in the following sections.

4.1.1 Step 1: identify activities and outputs

When we analyse the case studies that are described in Chapter 3, we can identify a number of activities that most or all of the four cases have in common. These activities are described in Table 9, as well as the outputs that are related to these activities. The identified activities are not necessarily chronological in the order as they are presented. Our research focusses on prosumer communities with an emphasis on local sustainable energy, although we do recognise that some initiatives have a broader scope and probably another starting point.

Table 9: Identified activities and outputs of prosumer community case studies analysis

No	Activity	Description and outputs
1.	***Community formation***	The group of primary participants establishes a legal entity (i.e. cooperative UA) as a local organisational platform for collective sustainability activities. The cooperative is open for membership where each member has an equal say.
2.	***Member recruitment***	People are invited to become member of the prosumer community in order to create a local social base and broad support for the initiative. Several promotional activities are executed.
3.	***Working groups formation***	Working groups are established, each focussing on a specific activity within the community. Working group staff is recruited, mostly volunteers, based on expertise, skills and preferences. Working groups are responsible for realising specific goals of the community.
4.	***Energy supply organisation***	Members are invited to purchase sustainable energy via the prosumer community. A cooperative retailer or a green retailer is contracted, where the prosumer community acts as a reseller.
5.	***Service portfolio offering***	Members are offered a portfolio of services (e.g. collective PV purchase, advice services) to stimulate active sustainable behaviour (e.g. produce renewable energy, save energy). The prosumer community reliefs members by providing information and advice, possibly leading to energy savings and cost savings.
6.	***Neighbourhood greening organisation***	People in a neighbourhood are stimulated to actively participate in activities to make their neighbourhood more sustainable.
7.	***PV panels for social housing organisation***	Tenants are enabled to profit from lower energy bills through sustainable energy generation. The PV panels are installed and owned by the social housing corporation.
8.	***Prosumer community shop establishment***	A community shop provides local visibility and offers a low threshold for the public to collect information on the initiative or receive advice on various sustainability subjects.

No	Activity	Description and outputs
9.	***Collective energy generation organisation***	Members are invited to participate in a collective energy generation project (e.g. local solar park) through buying shares. The participants receive a yearly fee for their shares and/or a tax rebate for the produced energy.
10.	***Smart grid pilot organisation***	Members are provided with tools to get insight in their energy behaviour and to actively control their energy consumption. The goal is to create insight, awareness and behavioural change, next to generating sustainable energy and financial savings.

Although the prosumer community initiatives differentiate in approach, size and environmental setting, the activities shown in Table 9 are generalizable for all initiatives. The activities resulted in a variety of outputs such as a prosumer community cooperative organisation, PV panel installations for households and companies, employment for local installation companies, information and consultation for people on energy savings, and the opening of a local prosumer community shop.

4.1.2 Step 2: reconstruct the sequence of events

In the first step, ten activities and their outputs were identified. As a next step, for each activity we reconstruct which actions and events have been performed to come to these outputs. The problems and bottlenecks that prosumer communities ran into are also highlighted.

Activity 1 – Formation of prosumer community

After a core group of primary participants found each other in a common goal, namely to locally organise sustainable energy provision, they started to discuss what would be their target settings. The core values of the initiative and the goals for the future were formulated. The formulated mission, vision and goals are used as fundaments for the message that is put forward towards the various target groups.

All four initiatives decided to establish a cooperative with limited liability. The cooperative form was chosen because it fits to the basic principles of the bottom-up initiatives: empowering their members to get control over their own energy. Limited liability is chosen because it protects the members against third-party liability, thus preserving them for large financial risks. The cooperative is presided by an elected board. Cooperative members have an

equal say in the general assembly where the members decide on the course of events within the prosumer community. Each cooperative decides who is eligible for membership, for instance whether companies are admissible for membership and under which conditions. In all initiatives members had to pay a membership fee, partly for covering the costs of the community activities and partly as a sign of commitment. In the first phase of the prosumer community a business plan was formulated where the goals and targets are translated into concrete plans. For this activity contact was sought with other initiatives to exchange experience and expertise and to learn from each other.

The encountered problems for this activity are mainly related to lack of expertise on issues like legal formats and for setting up a realistic business plan. Finding the right information and judging its credibility was considered to be rather troublesome.

Activity 2 – Member recruitment

All initiatives acknowledged that broad public support and (active) member participation is crucial for reaching their goals. The public was invited to support the initiative and become member. To realise broad public support a concise and appealing message was formulated for enticing people to join the initiative. A number of core elements of the message can be identified when looking at the four cases: 1) appeal to the sense of urgency of energy transition through creating local sustainable energy supply, 2) the local identity of the initiative, 3) the empowerment of local economic activities, 4) the yields are reinvested locally and do not flow to distant shareholders, 5) complete authority for the members. Various communication channels were used to publish the message like a website, newsletters and news coverage in the local press. Information sessions were organised, ranging from living room meetings to public meetings in community centres. Large scale events were used for publicity by renting a stand at a fair or at a market place. At all occasions folders and other PR materials were printed and distributed.

The case study prosumer communities ran into the issue of how to reach the broad public. Getting the early adopters and early majority aboard was fairly easy. But how to convince the late majority, who represent the larger part of the potential member target group, was experienced to be far more complex.

Activity 3 –Working groups formation

For carrying out the various activities the case study prosumer communities organised a number of working groups, each focussing on a specific subject related to one of the formulated targets. In first instance working group participants were recruited as much as possible from within the own member

group, and otherwise via the social network of the members. The following working groups can be identified: 1) PR & communication, 2) energy advice, 3) energy purchase and supply, 4) collective PV project, 5) smart grid pilot project. When necessary the members of the working groups receive extra training in order to be better equipped for the tasks they have to perform.

Volunteers are considered to be the lubricant that runs the engine of prosumer communities. Finding people with the right skills and expertise for the various working groups is seen as a potential barrier for successfully operating the working groups.

Activity 4 – Energy supply organisation

All studied prosumer communities aim to locally produce sustainable energy for the people in their region. As long as they are not yet self-supportive in their energy needs the energy supply is organised via a third party energy retailer. The cooperative acts as reseller for a selected retailer (LochemEnergie, Zeenergie) or as a reseller of an energy cooperative with a supply license (TexelEnergie, Grunneger Power). The prosumer community negotiates with the retailer which tasks are outsourced to the retailer, like invoicing, collections or customer services, and which tasks are the responsibility of the prosumer community, like customer recruitment. Legally the retailer is responsible for the correctness of the bill.

The prosumer communities do not claim that their energy supply offering is the cheapest in the market place though fairly competitive. Their members are offered a rebate on their bill when they have a contract with the selected retailer. In turn, the community receives a yearly compensation for each of their members' supply contract. Through the cooperative organisation structure of the prosumer community the energy supply activities have a non-profit motive. The members have a direct say on the operational management and decide on how any revenues are being invested.

The incorporation of energy supply within the prosumer community asks for proficient knowledge of the complex energy business. The complexity and involved risks are illustrated by the bankruptcy of Trianel, as is described in Section 3.2, where the white label construction almost caused the bankruptcy of a number of prosumer communities. For some communities this incident triggered a first step towards professionalization of the organisation. But finding people with the right skills and expertise is not always easy. Furthermore, appointing and paying professionals within a predominantly volunteer-run organisation may lead to internal discussions and tensions.

Activity 5 – Service portfolio offering

All four prosumer communities offer a service portfolio to their (potential) members, including a cluster of information and advice activities, to make it more attractive to become a community member. Energy supply is one component of the service portfolio. The service portfolio is intended to support and unburden people to make the right decisions with respect to purchasing sustainable energy, as well as for acquisition of sustainable energy installations and taking measures for saving energy. Many people do not oversee the overwhelming offer of, for instance solar panel installations: which panels and installation company to choose? Which information is trustworthy? In this case the prosumer community acts as an intermediate and trusted party by making a preselection of local based solar panel installation companies. Community members qualify for a rebate when they select one of the preferred installers, while the prosumer community receives a compensation for each installation. PV panels are also made available for tenants through cooperation with local social housing corporations. Next to solar panel advice, prosumer communities also offer services like leasing PV panels, energy labelling advice, scans for possible energy savings, support for neighbourhood projects and advice on LED lights replacement.

For this activity people with the right skills and expertise are needed, who or not always available within the own ranks. Specifically, technical expertise and knowledge of financial and regulatory issues, next to advice skills are desirable, although seldom bundled within one person. When necessary, the volunteers involved in the implementation and execution of the service portfolio receive extra training in order to be better equipped for the tasks they have to perform.

Activity 6 – Neighbourhood greening organisation

Each initiative in the case studies organised a variety of activities and events to inform citizens and businesses on the possibilities to become more sustainable at a local level. Provision of information and advice is, above all, intended as an invitation to join the initiative. A specific activity is the organisation of living room meetings, where people from the same street or neighbourhood meet to discuss and exchange information and experiences in an informal atmosphere. These meetings appeal to the social factor of the prosumer community. In an urban area like the city of Groningen, activities are being deployed specifically at neighbourhood level because that is the environment where people meet each other on a daily base. The social context is an important factor for people to identify oneself with the activities of a prosumer community, thus organising these activities possibly lowers the threshold to join.

Activity 7 – PV panels for social housing organisation
People who rent a house are not the owner, and therefore they are not allowed to install solar panels on the house. Prosumer communities developed a construction, in cooperation with social housing corporations, to enable tenants to profit from the yields of solar panels on their roof tops. In this case the prosumer community acts as an intermediate and facilitator for the collective purchase of solar panels, while the housing corporation takes care of the financial investments as the owner of the installations. The monthly rent for the tenants is possibly raised but this increase is amply compensated by a lower monthly energy bill. The participation of the prosumer community is important because of their local presence and reputation, which is a major asset for convincing tenants to participate.

In this activity both the social housing corporation as well as each of its individual tenants, need to be convinced to participate. Similar expertise and skills as with the service portfolio activity are needed for the involved volunteers.

Activity 8 – Prosumer community shop establishment
Three of the case study communities have a local shop that can be visited by interested people. In most cases, this is also the work and meeting place for the active members of the community. The physical shop makes the prosumer community more visible and accessible to the general public. It aims to provide a low threshold for the public to visit and receive information and advice on local sustainability activities.

Finding a suitable location for a shop, which is also affordable for the prosumer community, is a possible hurdle for this activity. In our case studies the locations were made available by the municipality or an estate agent, sometimes for temporarily use at no costs or for a favourable price (e.g. due to lack occupancy). The availability of volunteers for staffing the shop largely determines the opening hours of the shop.

Activity 9 – Collective energy generation organisation
Locally generating energy via large-scale, collectively owned installations is one means to realise the sustainability goals of an initiative. All four initiatives have made plans for realising one or more projects. Both TexelEnergie, Grunneger Power and LochemEnergie are in the process of implementing a large scale solar park project. Members of the prosumer community are invited to invest in a collective energy project like solar panels on a community building or a solar park on a piece of waste land, or in one or more wind mills in the vicinity of the community. The generated energy is delivered

to a contracted retailer. Different constructions are possible how the production yields can be settled with the members or shareholders. Settlement via the postal code rose regulation[28] is one of the options, taking into account that the participants must reside in one of the adjacent postal code areas. In case of a wind mill or wind mill park the participants receive a yearly return on their investment, while the other yields are divided amongst the members and other stakeholders.

It proved to be a quite complex task for prosumer communities to realise a large-scale energy project without the participation of professional project developers. There is a large diversity of aspects that need to be arranged like finding a suitable location, applying for the necessary permits, organising financial funding and, last but not least, overcoming the objections of the neighbouring people, specifically when wind mills are involved. Next to the objections, the uncertainty on legislation and subsidy regulations for the longer term makes it very hard to make a solid project business case. Support of professionals is almost indispensable in such complex projects. When not available inside the community, these experts/expertise have to be recruited from outside for instance via personal networks, professional associations, or via social media. Information and expertise sharing with other initiatives is considered to be very valuable.

Activity 10 – Smart grid pilot project organisation

Local sustainable energy production for the local community is one of the main targets of the four prosumer communities that were studied. The initiatives acknowledged that energy consumption should follow the availability of sustainable energy as much as possible, meanwhile recognising that advanced technology is needed to support people in realising this. The prosumer community is offered as a pilot environment where new energy technologies and services can be tested. The prosumer community's customer base is attractive for testing new services while they represent a group of mostly dedicated people who are located in a demarcated area. Furthermore, prosumer communities use the smart grid pilot projects as a signboard to present themselves as being a frontrunner in sustainable developments. The smart grid technologies that are being tested were developed by different consortia, consisting of knowledge institutes, technology developers (both hardware and software), and representative actors from the energy business (e.g. grid operator, retailer). Due to the experimental character of the pilot projects the prosumer communities have agreed upon operational guarantees

[28] Detailed information on the postal code rose regulation can be found in Appendix 1.

from the actors, in order to prevent failure of the participants' energy provision. In case of failure backup services need to be provided.

In our four case studies the prosumer communities operated as the pilot environment for a smart grid project. The projects' consortia were in the lead and took care of the technical installations and the operational management and coordination, while the prosumer community facilitated the recruitment and selection of participants, as well as the communication activities. Participants indicated that a clear division of roles and responsibilities between the prosumer community and the consortia partners was considered to be essential for support of the pilot and for preventing lack of clarity. It should be clear who to contact for which issues. Due to the temporal character of the pilot projects it is unclear whether the provided technologies and services will be available and supported for the long(er) term.

Resume of step 2: reconstruction of sequence of events
In this step we further zoomed in on the various activities of the prosumer communities case studies. The identified actions and events, and the order in which they were executed, were not exactly the same for all four cases. But in general terms, as an abstraction of the cases, the reconstruction is generalizable for prosumer communities in common, covering the overall transition path of the activities. In Section 4.2 we will use these results for describing the various phases of the prosumer communities growth path.

We also identified which problems and barriers were encountered in the various activities. Most problems were related to lack of knowledge and lack of expertise on various energy related subjects that are needed for successfully deploying the activities. Furthermore, access to needed information, and being able to judge the credibility of it was also considered to be troublesome, which hinders the progress of the decision making process. We will further address this in step 4, where we identify the decisions, eventually leading to the requirement specification in Section 4.3.

4.1.3 Step 3: analyse the outcomes

In this section the direct and indirect impact of each of the activities on the prosumer community is described by analysing the outcomes, described in step 1.

Activity 1 – Formation of prosumer community
The outcome of the formation of a prosumer community is a legal entity. The statutes of the community describe the organisational structure as well as the

authorisations and responsibilities within the community. The legal status provides authority to the prosumer community for consulting and negotiating with various stakeholders that are involved in the prosumer community value network. Furthermore, the legal entity serves as a placeholder where people can identify themselves with, and as an organisation which they can join. The prosumer community operates as a platform for all kinds of activities that are related to realising the goals of the community.

Activity 2 – Member recruitment
The outcomes of the member recruitment process were a website, newsletters, coverage in the local press and a variety of printed PR material. The ultimate outcome is that people join the initiative and become a member. Membership is very important for the prosumer community while membership commitment provides the social basis, giving prosumer communities the authority to act as a representative of a widely supported initiative. The broader the support, the higher the power to act. Furthermore, membership fees generate a source of revenue flows.

Activity 3 – Working groups formation
The outcomes of this activity are various working groups with delegated responsibilities. Each working group is focussed on realising a specific activity that contributes to reaching the goals of the community. The dedicated groups increase the operational strength of the community.

Activity 4 – Energy supply organisation
The direct outcome of the energy supply activity is that members purchase and use sustainable energy. Furthermore, they are stimulated to invest themselves in sustainable energy generation facilities in order to make them contribute to the community's goal setting of becoming energy self-supportive. Indirectly, the energy supply reseller construction generates revenues for the prosumer community which can be invested in sustainable projects within the community.

Activity 5 – Service portfolio offering
Prosumer communities offer various services to stimulate energy saving measurements and to support people in generating sustainable energy themselves. As a direct result, community members installed PV panels on their roof tops, they invested money in insulation measurements resulting in energy savings and saving money. Furthermore, advice services provided people insight in their energy habits which probably resulted in more energy-consciousness behaviour. Another intended outcome is that through the spread of word-of-mouth other people will be attracted to join the initiative.

Furthermore, the local economy is stimulated through the created employment for local installation companies.

Activity 6 – Neighbourhood greening organisation
Activities organised in the neighbourhood or at street level increase the chance that people feel attracted to the prosumer community, while it is easier to identify oneself with people in their near vicinity. Seeing is believing, next to collaboration, works as a stimulus for activation where otherwise people would sit back and wait. Working together on realising collective results that are profitable, not only for the individual participants but also for the larger neighbourhood community, creates social cohesion and increased neighbourhood liveability, next to the contribution to the formulated sustainability targets of the community.

Activity 7 – PV panels for social housing organisation
The outcomes of this activity are that tenants receive a lower energy bill, while the social housing corporations contribute to their sustainability goal settings. The prosumer communities satisfy their goal of making sustainable energy locally available for everyone. Local installation and maintenance companies take advantage while it creates economic activities and employment.

Activity 8 – Prosumer community shop establishment
The prosumer community shop offers a low threshold for the public to get information and advice on the local sustainability possibilities.

Activity 9 – Collective energy generation organisation
The outcome of a collective energy generation project is the delivery of locally generated sustainable energy, which can directly or indirectly be settled with the members or stakeholders in the project. It also provides people, who do not have the possibilities on their own premises, to participate in sustainable energy generation. It results in a higher share of sustainable energy, while the participants receive compensation in the form of sustainable energy, or financially in the form of tax deduction (i.e. postal code rose regulation) or a return on their investments. The prosumer community profits while it receives a share of the yields, which again can be reinvested in other sustainability projects within the community. Furthermore, employment is generated for local installation and maintenance companies.

Activity 10 – Smart grid pilot project organisation
Although the various smart grid pilot projects differ in size, lead time, used technology and implemented services, there are a number of common

outcomes that can be identified. The participants were provided with an interface on a PC, tablet or wall-mounted display which gave them insight in their actual energy consumption. Furthermore, incentives were provided through a 24 hours forecast of energy price or availability of sustainable energy. The forecasts enabled participants to adapt their energy behaviour to the most favourable moments (e.g. lowest price, availability of sustainable energy). Matching algorithms were tested to explore whether demand could be adjusted to the available supply of intermittent resources by actively switch on/off controllable devices (e.g. heat pumps, electric vehicles, smart appliances). This way network peak loads could be avoided. The first results show that participants actually are positively stimulated to change their energy behaviour when feedback is provided, thus allowing them to save both energy and money. Smart matching algorithms seem to help prevent local network overload, which is potentially very beneficial while expensive infrastructure upgrades can be deferred or even can be made superfluous. As part of the IPIN program, the pilot projects also yielded valuable input for establishing which technologies, services and business models are most successful and should be adapted in the future energy system. Encountered institutional and regulatory hurdles contribute to the revision process of the existing legislation. And, as some people expressed, it was just fun to participate!

Resume of step 3: analysis of the outcomes

Analysing the outcomes shows the potential direct or indirect effects and added value of each of the prosumer community's activities. The activities yielded a variety of outcomes with a direct or indirect impact on the community, ranging from a legal entity as a platform for the community's activities, to delivery of sustainable energy and installation of PV panels at members' premises. Although the outcomes are not specifically quantified, they give an indication where specific facilitation is needed.

4.1.4 Step 4: identify the decisions

In step 1, 2 and 3 of this chapter we identified the various activities of the case study prosumer communities, as well what actions and events had been performed to realise these activities, and what were the outcomes. In step 4 the activities and their sequence of events are further analysed in order to identify which decisions were involved in these activities and what was needed to make these decisions. Some of the decisions were explicitly mentioned and discussed in the case study interviews, others were derived by the researcher by analysing the activities. The relevance of identifying the decisions is that we want to come to a design for decision enhancement.

In the following sections for each activity the decisions are listed along with the identification of what was needed to make the decisions.

Activity 1 – Formation of prosumer community

Decision	What was needed
Decide on core values and targets	- Group of like-minded people
Decide on legal form	- Knowledge of possible legal forms - Access to notary - Examples of pioneers (e.g. statutes)
Decide on business plan	- Business plan expertise - Energy technology expertise - Environmental planning expertise - Knowledge of local opportunities and feasibility of various scenarios (energy technologies, environmental planning, political, legal) - Access to information on the size of the potential target groups (source: municipality) - Access to data sources on local energy consumption and expenditures (source: grid operator) - Examples of pioneers (e.g. handbook, templates)

Activity 2 – Member recruitment

Decision	What was needed
Decide on composition of working group for member recruitment	- Availability of people/volunteers with right knowledge, skills and affinity (PR and marketing)
Decide on core message to bring forward	- Message should connect to core values and goals - PR and marketing knowledge
Identify various target groups that need to be addressed	- Knowledge of customer segmentation - PR and marketing knowledge
Decide on communication channels to be used	- Availability of people/volunteers with right knowledge, skills and affinity - PR and marketing knowledge - Availability of budget

Decision	What was needed
Decide on PR material to be developed	- Availability of people/volunteers with right knowledge, skills and affinity (e.g. website design, web development and content management, graphic design) - PR and marketing knowledge - Availability of budget
Decide on events for recruitment	- Overview of local events and their potential visitors - Availability of information meeting locations (e.g. community building, neighbourhood centre)
Decide on membership registration process	- Volunteers responsible for customer registration - CRM tool (e.g. Excel, professional CRM software)

Activity 3 – Working groups formation

Decision	What was needed
Decide on which working groups are needed	- List of desired working groups - Prioritisation which working group(s) to start with - Availability of people/volunteers with the right knowledge, skills and affinity - Examples of pioneers
Decide on which expertise is needed for the working groups and where the expertise can be found	- Knowledge on which expertise is needed - Availability of people/volunteers with the right knowledge, skills and affinity - Examples of pioneers
Decide on tasks and (delegated) responsibilities of working groups	- Examples of pioneers
Decide on training for working group members	- Overview of needed and available expertise - Overview of available training programmes - Budget available - Examples of pioneers

Activity 4 – Energy supply organisation

Decision	What was needed
Decide on third party supply construction	- Knowledge and expertise on energy supply constructions - Expertise on energy business market (e.g. legal liability, financial obligations, business planning) - Legal and fiscal knowledge regarding self-supply (before and after the meter) - Examples of pioneers
Decide which retailer to work with	- Knowledge and expertise on energy supply constructions - Overview of available retailers - Invite retailers to provide offer - Assessment of retailers' offers - Negotiation power - Examples of pioneers
Decide on contract with retailer	- Knowledge on energy contracting - Negotiate on rebate for members and compensation for prosumer community - Examples of pioneers
Decide on in/outsourcing (administrative) tasks	- Knowledge on needed in-house expertise (e.g. CRM, invoicing, billing) - Availability of people with the required expertise - Knowledge on needed software - Examples of pioneers
Decide on how to recruit customers	- Formulate the key message why customers should choose prosumer community for energy supply (distinctive USPs – local, sustainable, not for profit, etc.)
Decide on support	- Division of roles with retailer - Availability of people for help desk - Training of help desk staff

Activity 5 – Service portfolio offering

Decision	What was needed
Decide which services to offer	- Knowledge on what services can be offered - Examples of pioneers
Decide which people and expertise is needed	- Knowledge of needed expertise - Overview of available people and their expertise
Decide on how to organise the service portfolio	- Organisational expertise - Promotional activities for service offering - Examples of pioneers
Decide on training for staff members	- Overview of needed and available expertise - Overview of available training programmes - Budget available - Examples of pioneers
Decide on selection criteria for preferred supplier(s)	- Overview of available suppliers (e.g. installation companies) - Proficient knowledge of which components are needed for the service portfolio - List of selection criteria
Decide on selection of preferred supplier(s)	- Knowledge and expertise to judge the suppliers' offers - Invite suppliers to provide offer - Assessment of suppliers' offers - Negotiation power - Negotiate on rebate for members and compensation for prosumer community - Knowledge on contracting - Examples of pioneers

Activity 6 – Neighbourhood greening organisation

Decision	What was needed
Decide which neighbourhoods to support	- List of active neighbourhoods - A group of active people in the neighbourhood (ambassadors)
Decide on the role of the prosumer community	- Availability of volunteers in the prosumer community - A work plan from the prosumer community

Decision	What was needed
Decide on consultation with neighbourhood which activities to deploy	- A group of active people in the neighbourhood - Volunteers in the prosumer community - Expertise on potential neighbourhood projects
Decide who is going to participate	- Volunteers in the prosumer community, preferably from the neighbourhood

Activity 7 – PV panels for social housing organisation

Decision	What was needed
Decide which social housing corporation(s) to work with	- List of local social housing corporations - Contact and discussion with housing corporations - Knowledge of corporations' business
Decide on division of roles	- Who is primary contact with tenants (e.g. tenants association) - Make use of the prosumer community's preferred suppliers? - Examples of pioneers
Decide which neighbourhood is eligible for installing solar panels	- Identify suitable housing types - Identify suitable housing locations
Decide on strategy for recruiting tenants that are willing to participate	- Local contacts with tenants (e.g. tenants association) - Organising information meetings - Compose and distribute information material - Examples of pioneers
Decide on the installations	- Installation types - Number of participating houses - Selection of installation company - Selection of maintenance company
Decide on the financial construction	- Who is investing in the panels - Subsidies available - Who owns the panels - Maintenance contract - What are the benefits for the tenants - What are the benefits for the prosumer community - Examples of pioneers

Activity 8 – Prosumer community shop establishment

Decision	What was needed
Decide on suitable location	- Availability of suitable location - Vacant location available from local municipality or estate agent - Contract with letter
Decide on available budget	- Budget for housing
Decide on opening hours for public	- Availability of staff

Activity 9 – Collective energy generation organisation

Decision	What was needed
Decide on the regional potential and possible locations for collective energy generation projects	- Knowledge on suitable locations (e.g. waste land, roof tops of community buildings) - Contact with land/building owners, municipality and province - Examples of pioneers
Decide which energy technology to implement	- Knowledge of energy technologies - Availability of suitable location - Permits
Decide which stakeholders should be involved	- Contact persons with land/building owners, municipality and province, neighbouring people, grid operator, retailer, financial partners, etc. - Examples of pioneers
Decide on which permits are needed	- Legal and fiscal expertise - Contact persons with municipality, province, grid operator (e.g. for permit regulations, environmental planning)
Make business plan and decide on the feasibility of the projects	- Business plan expertise - Legal and fiscal expertise - Expertise of energy business - Expertise of energy technologies - Expertise of quality and certification norms - Agreement with stakeholders - Realistic prognoses on expected yields, exploitation and maintenance costs - Examples of pioneers

Decision	What was needed
Decide on financial construction for project funding	- Financial expertise - Knowledge on financial constructions (e.g. via members, crowd funding, external financers, subsidies, etc.) - Agreement with retailer - Examples of pioneers
Decide on installation company that will implement and take care of maintenance of the project	- Technical expertise - Overview of (locally) available installation companies - Invitation to submit offers - Judgment and selection of offers - Coordination with grid operator (e.g. grid connection, metering installation) - Contract management - Examples of pioneers
Decide on project management of the construction and installation process	- Project management skills - Examples of pioneers
Decide on how to fill-in the exploitation and daily operational management of the project	- Operational management skills - Monitoring of installation (asset management) - Metering of production - Settlement of yields (e.g. billing and invoicing) - Maintenance and technical malfunctioning agreement - Service desk contract agreement - Coordination with grid operator and retailer - Examples of pioneers

Activity 10 – Smart grid pilot project organisation

Decision	What was needed
Decide whether or not to participate in a smart grid pilot	- Does it fit to the goals - Approval of the cooperative members
Decide on partner selection for the pilot	- In practice the prosumer communities are approached for participation

Decision	What was needed
Decide on the terms and conditions for participation	- Size of pilot (minimal/maximum number of participants, duration) - Costs and yields - Responsibilities and authorities - Guarantees for security of supply
Decide on guarantee for energy security of supply and appropriate back-up facilities	- Professional and trustworthy partners - Availability of back-up facilities - Availability of professional help desk
Decide on recruitment and selection of the pilot's participants	- PR materials - USPs and added value for participants - Information sessions - Selection and registration process
Decide on contracts with the participants	- Information from partners - List of terms and conditions - Approval from participants - Contract with participants
Decide on how to monitor the results	- Privacy regulations - Who owns the collected data - Approval from participants
Decide how to communicate with participants during pilot	- Agreement on division of roles between consortium partners and community - Communication channels available - Help desk available for first and second line support - Feedback to participants on progress
Decide on installation process	- Information from partners - Communication to participants what will be installed at their premises - Coordination of installation process
Decide on what happens to installed base after the pilot is finished	- Extended support - Contractual agreement

Resume of step 4: identification of decisions

This step yielded a list of decisions that were involved in the various activities. Material (e.g. documents, money) as well as non-material (e.g. expertise, social basis) resources were needed for making the decisions. Overall, it can be noted that information from a broad range of subjects was needed for decision making, as well as people with specific expertise and skills.

Furthermore, information exchange and sharing knowledge and expertise with peers, specifically with the frontrunners and intermediate organisations, were all considered to be very important.

4.1.5 Step 5: identify who were involved

In this step we identify which actors were involved in each of the activities and what was their specific role. This way we get an overview of the actors in the prosumer communities' value network.

Activity 1 – Formation of prosumer community
In this activity only a small group of people is involved who found each other in a common goal and drive to realise local sustainable energy provision for and with the local people. They presumably have different professional backgrounds but they agree on how to realise the formulated goals. For the establishment of a legal entity in the form of a cooperative the formal documents have to be deposited at a notary. Furthermore, contact is sought with frontrunner initiatives to exchange knowledge and experience. Intermediary parties such as ODE Decentraal[29] and HIERopgewekt.nl can play an important role as a resource for information and advice, although these organisations were not yet operational when the prosumer communities of our four case studies started.

Activity 2 – Member recruitment
Publicity is essential for this activity. Contact and a good relationship with the local press and media is therefore important. The local authorities, such as the municipality, also play an important role as a facilitator and supporter of the initiative. Neighbourhood community centres can be used for information sessions. Volunteers from within the prosumer community are being mobilised for the various promotional activities that are focussed on the target groups: local citizens and companies. Internet and social media are also being used as channels for promotional activities. Volunteers with skills (e.g. website building, content management, etc.) and affinity with these media types are needed. Volunteers with a PR and marketing background need to be available for drafting a communication plan and for developing promotional material.

[29] ODE Decentraal was established in April 2015 as a merger between two large interest groups, ODE and e-Decentraal, both representing citizens and cooperative sustainable energy initiatives. https://www.duurzameenergie.org/, last accessed 12 June 2016.

Activity 3 – Working groups formation
For the formation of working groups, volunteers with a diversity of backgrounds and skills are needed, depending on the subject that is covered by the working group. Knowledge and expertise is needed in the areas of energy technologies, finance, legal and fiscal issues, project management, and PR and communications. A training centre is called in whenever extra education is needed for the volunteers. When necessary external experts are approached.

Activity 4 – Energy supply organisation
The role of an energy supply licensee is essential. The licensee is committed to a number of legal obligations such as program responsibility, the obligation to supply energy with reasonable tariffs and conditions, and the requirement to provide information. The prosumer communities in our case studies act as reseller of a commercial retailer and respectively a cooperative retailer. Contact with frontrunner initiatives or with an intermediary is important for exchanging information and expertise on this complex subject.

Activity 5 – Service portfolio offering
The main actors that are involved in the service portfolio activity are the installation companies that act as the preferred suppliers of the prosumer community. They take care of the installation of sustainable energy facilities such as PV panels or low-energy devices at the premises of the community members, and they possibly provide maintenance support. A trainings centre is involved whenever extra education is needed for the volunteers.

Activity 6 – Neighbourhood greening organisation
Next to the people in the neighbourhood and the prosumer community's volunteers no external parties are directly involved in this activity.

Activity 7 – PV panels for social housing organisation
In this activity the prosumer community directly works with a social housing corporation and with the tenants. Depending on the division of roles, the prosumer community or the housing corporation is dealing with a PV installation company. Housing corporations often have their own maintenance department, but it is not obvious that they have ample experience with PV panel installation.

Activity 8 – Prosumer community shop establishment
The involved party in the prosumer community shop is the one who lets the location or who makes the location (temporarily) available. In the studied cases it was the municipality or an estate agent.

Activity 9 – Collective energy generation organisation

Setting up a collective energy project is quite a complex activity with multiple parties involved. First of all a location needs to be available such as a community building or a piece of waste land, where the building owner or the land owner needs to be involved. This can be a private person or a company, a public body (e.g. school, sporting accommodation) or public authority (e.g. municipality). An installation company is involved for the realisation of the facilities, and the grid operator is incorporated for the grid connection and the metering installations. Furthermore, an agreement has to be made with the energy retailer for the purchase of the generated energy. For arranging the finances possibly the prosumer community has to apply for subsidies at the party concerned, or it has to deal with the tax authorities when the postal code rose arrangement is involved. Possibly external financers are involved like a bank, private investors or an investment company, or a crowd sourcing platform. Local authorities like the municipality or the province play a role when permits are needed for the environmental planning of the generation facilities. Due to the complexity of collective energy generation projects it is likely that an external project manager needs to be involved, when this expertise is not available within the prosumer community. The expertise and experience of other initiatives are considered to be very valuable.

Activity 10 – Smart grid pilot project organisation

When analysing the smart grid pilot projects of the four case studies a number of parties can be distinguished. The municipality and the province play the role of supporter and stimulator, and in some cases as provider of space for collective energy generation facilities. Knowledge institutes, like universities, DNV GL and TNO, play the role of technology concept developer and as pilot evaluator. ICT companies are involved who develop the software that connects the various components in the pilot project and provides the intelligence for optimal balancing of supply and demand. Device suppliers are incorporated that deliver the peripheral equipment such as smart thermostats or smart displays for the end-users. Furthermore, hardware providers are involved who develop sensors and actuators that are needed for the active monitoring and control of the end-user appliances and network devices. Installation companies take care of the installation and proper functioning of the various components in the pilot projects, such as smart white goods, heat pumps, solar panels, micro-CHPs, etc. In the case of Zeenergie a wind mill park operator and a dairy farm, who operates a biomass fuelled CHP installation, are participating in the pilot project. Furthermore, grid operators and retailers are involved in their specific role as infrastructure provider and respectively (back-up) energy retailer. Depending on the specific case study, one of the parties is responsible for the overall project management.

Resume of step 5: who were involved

Figure 8 gives an overview of the actors that were involved in the various activities in the prosumer community case studies. This overview is an example of a value network of prosumer communities.

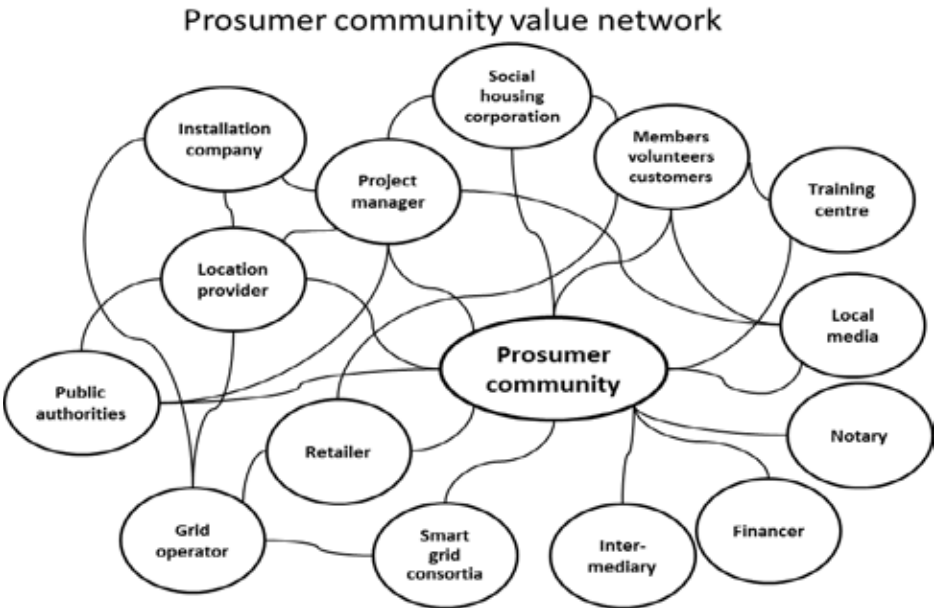


Figure 8: Example of a prosumer community value network

4.2 Growth path of prosumer communities

In the first three steps of the case study analysis we identified the various activities and reconstructed the sequence of events that were performed so far by the four explored prosumer communities, next to the outcomes of these activities for the prosumer community. When examining the activities, logical clusters can be made that chronologically belong together, where we identify two distinctive phases that are characteristic for the prosumer communities' growth path.

- In the first phase the idea of a prosumer community is generated and discussed by a core group of people, who then decide to establish a legal entity as a platform for realising their sustainability goals. A first business plan is set-up where the goals and targets are being formulated, along with a plan of approach how these goals could be realised. The organisation is characterised by an informal structure with relatively general roles by each member, mostly volunteers.

Financial means are absent or very low, and the available knowledge of the energy sector is relatively low.

- In the second phase the plan is put into action by organising working groups, thus establishing a more formalised organisational structure. Marketing and customer care activities are intensified for member recruitment. A service portfolio for the community members is composed and operationalised, including organising energy supply, in order to further expand the prosumer community. The prosumer communities took the first steps to realise collective energy generation projects, including efforts to gather the needed financial resources, which ultimately should result in self-supportive sustainable energy provision for the local prosumer community, as far as possible. Furthermore, the prosumer communities participated in a smart grid pilot project, where new technologies and innovative services were being tested, with the intention to contribute to a future sustainable energy system.

Life cycle phases of prosumer communities

Models on organisational life cycle phases have been amply described in literature, and in general it typically consists of "four identifiable but overlapping phases of *start-up*, *emerging growth*, *maturity* and *decline or revival*" (Jawahar & McLaughlin, 2001). These phases are similar to the phases *introduction*, *early growth*, *take off* and *maturity* as identified by Rogers, who studied the diffusion process of innovation (Rogers, 1995)[30]. Lattemann & Stieglitz (2005) studied the life cycle phases of community-based projects. They characterise the various phases, which we will adopt for the growth path of prosumer communities, as follows:

- In *the start-up phase* the main concerns are on developing and implementing a business plan, obtaining initial financing, and entering the market place.
- In *the emerging growth phase* a certain degree of success has been achieved, and the main focus is on actively seeking expansion opportunities (e.g. investments, number of employees and customers, geographical expansion).
- *The maturity phase* follows the emerging growth phase and in this phase the critical mass is approached and growth rates will decline. Characteristics are strong cash flows and relatively few attractive investment opportunities.

[30] Another approach to look at organisational life cycles comes from transition theory (Rotmans & Horsten, 2012), where various transition lenses are being used: 1) Multi phase, 2) Multi level, and 3) Multi pattern.

- With *the decline or revival phase* the organisation enters a period of decline or transition. The demand for the traditional products or services is declining, and strategies of considering mergers, downsizing and layoffs are necessary for survival.

Prosumer community start-up and emerging growth phase

In the life cycle phase model, described by Lattemann et al. (ibid), we find the first two phases that we identified previously in this section:

- *The start-up phase, with an initial idea, setting up a legal entity, and working out a business plan, and;*
- *The emerging growth phase, with deployed activities such as member recruitment, setting up working groups, organising financial resources, realising collective energy projects, and participation in a smart grid pilot project.*

Prosumer community maturity phase

In our four prosumer community case studies we do not yet see the maturity and the decline or revival phases. Although we do not have empirical data available from our case studies, we can give a sketch of how a prosumer community in the future maturity phase may look like, based on input from the smart grid pilot projects that were described in the case studies in Chapter 3 and from various research projects described in literature (see also Chapter 2: Belhomme et al., 2011; Karnouskos, 2011a; Karnouskos, 2011b; Shandurkova et al., 2012; Kok, 2013; Geelen, 2014; Kobus et al., 2015).

In the maturity phase the prosumer communities' organisation will be run more business-like, and several employees will be hired. The maturity phase is reached when the number of members and customers of the initiative is hardly growing anymore and various sustainable energy projects will have been realised, which cover for a substantial part the energy demand of the community. Building cooperation with other stakeholders, such as municipalities, installation companies and project managers is an important activity. Smart grid technologies and smart energy services will be integrated in the daily operations of the local energy provision system. In the community we will find connected the premises of the community members (e.g. households, offices, companies), collectively owned communal energy generation facilities (e.g. PV park, wind mills, biomass installations), and collective energy storage facilities.

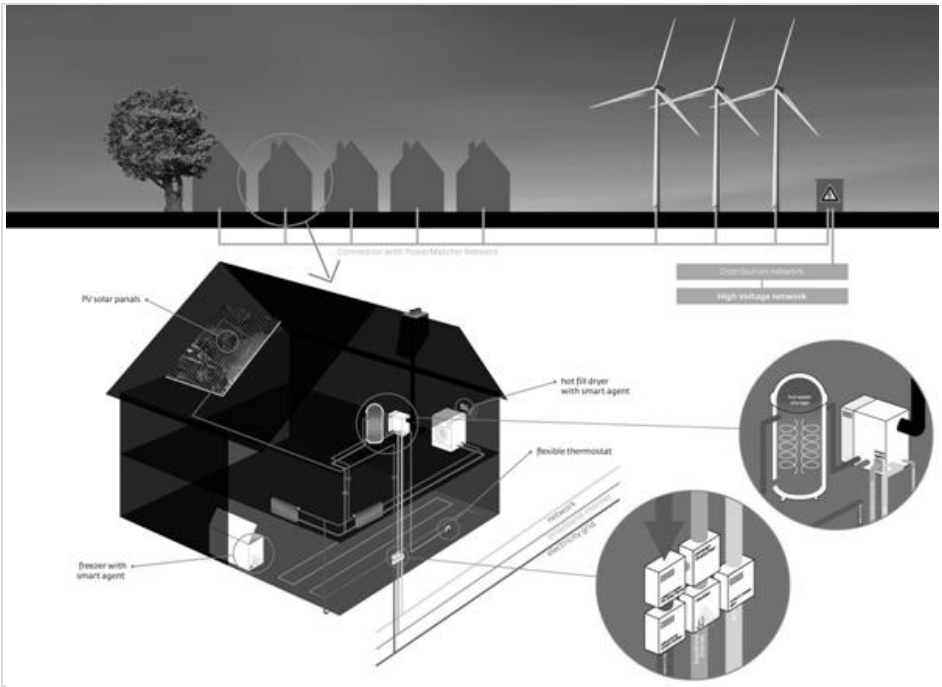


Figure 9: Example of a prosumer community participating house filled with smart appliances hot fill dryer, smart thermostat, PV solar panels and smart freezer (courtesy to PowerMatching City).

Energy balancing takes place at different levels, that is at micro-level within the member's premises, and at meso-level between the various participants within the community. Local energy storage facilities (e.g. electric vehicles, battery packs) can be used for temporarily storing the surplus of generated energy, which can be used at the moments when production falls behind at momentary demand. Sophisticated energy management services can be used to adapt energy usage to the momentary availability of energy (e.g. demand side management). Whenever there is a surplus or shortfall of energy within the community, the external energy market place can be used as a back-up facility.

In the maturity phase, in general, a community participant's premises is equipped with various energy components, such as energy generation facilities (e.g. PV panels, micro-CHP), controllable household appliances (e.g. smart appliances, smart plugs), and storage facilities (e.g. electric vehicle). The smart meter functions as the interface to the energy infrastructure (both electricity, gas, heat and water), while the home gateway operates as the interface to the external energy services environment. The home energy management system, which is operated by the end-user, is the central unit for

in-home energy monitoring and control. In turn, the home energy management system is connected to the community energy management system, which functions as the central coordinator between the various components within the prosumer community (see also Section 2.4 on smart energy technologies).

Prosumer community decline or revival phase

The decline or revival phase denotes a time frame of decline, where the prosumer community has to reorient itself on its position and it has to re-evaluate its business model, because the demand for its services is declining. The decline might have diverse causes like the emergence of disruptive technologies, changing legislation, or because individual prosumers have become fully self-supportive and the role of the community has become superfluous. In our research we will not further address this phase.

Resume of growth path identification

By analysing the activities that the case studies had in common, and analysing the sequence of events, we abstracted a generic understanding of prosumer communities. Using the organisational life cycle model (Jawahar & McLaughlin, 2001; Lattemann & Stieglitz, 2005) we found two life cycle phases in the prosumer communities' growth path up to date: the start-up phase and the emerging growth phase. A gradual transition to the next life cycle phase, the maturity phase, is emerging with the cautious initiation and first realisation of large-scale energy projects and the participation in smart grid pilot projects. But these are only the first steps towards a full-grown, possibly energy self-supportive prosumer community. By determining the prosumer communities' growth path life cycle phases, along with the related activities and sequence of events, we have found the answer to research sub question SQ1: how does the growth path of prosumer communities look like? Furthermore, we identified the stakeholders that play an important role in the value network of prosumer communities.

4.3 Generic requirements for prosumer community decision enhancement

The very essence of the exploratory study and its analysis is to provide a generic understanding of the research problem (i.e. the design issue to be resolved): what are the obstructions that hinder the development process of prosumer communities. And what is needed for enhancing decisions of prosumer communities in their growth path from idea and start-up, towards a mature energy community?

The analysis shows that prosumer communities operate in a multi-player value network (4.1.5), running into problems in different life cycle phases with often complex decision processes involved (4.1.4), while constantly seeking information, knowledge, tools and expertise that could help them solve the encountered problems. Based on these observations a number of generic requirements can be formulated that need to be taken into account when designing a solution for decision enhancement.

We ascertained that the development process of prosumer communities is a long way full of problems and complexities, where information and expertise from multiple disciplines and resources is needed. Prosumer communities seldom have knowledgeable people within their ranks that cover the full range of needed expertise, so support in finding the right information and expertise is desired. This leads us to the following requirement:

R1. Guidance: the solution must provide guidance to prosumer communities in finding the right information and expertise.

For most activities a substantial quantity of information is needed, which originates from a broad range of knowledge resources and fields of expertise. This information is usually not available in one place, which leads to the following requirement:

R2. Information access in one place: the information resources must be available, or at least accessible in one place**.**

In every phase of the growth path specific information, tools and knowledge is needed. To prevent users from information overload the information should be provided at the moment when it is needed.

R3. Just in time information availability: the solution must present the information in sync with the needs and demands of the user.

We want to provide a generic solution, which is available for multiple prosumer communities. Because the prosumer communities are largely locally oriented, and local circumstances for each initiative can be substantially different, we can formulate the following requirement:

R4. Location dependent information: information provided should be, when appropriate, locally or regionally demarcated.

The solution should be generically applicable and available for all prosumer communities, while at the same time it should be adaptable to the unique identity of each local initiative.

R5. **Ready-made versus custom-made:** the solution must be adaptable to the specific needs of the local prosumer community.

Specifically in the maturity phase, a large range of tools and services will be needed for monitoring and controlling energy flows and the various involved energy components within the community.

R6. **Tool and service selection:** the solution must provide a rich set of services and tools, which should be well-structured and organised in order to guide users in deciding on selection.

The needs and demands of individual members of the prosumer community are different from what prosumer communities at organisational level need.

R7. **Services for end-users:** specific tools and services should be made available for individual prosumer community participants.

The exploratory study revealed that there is a need for support and relief in the complexity of the energy business. Trust, control and usability were mentioned as key elements that need to be respected when decision enhancement facilitation would be outsourced or automated, which leads to the following requirement:

R8. **Trustworthy solution provider:** the party that provides the solution should be trustworthy, where users have the choice to decide on automatic control. Tools and services should be easy to use.

While interoperability and scalability are important aspects, the following requirement is added:

R9. **Standardisation:** standards should be used in order to guarantee interoperability and scalability of the solution.

Resume of requirement derivation for decision enhancement

Now that we identified the requirements for decision enhancement, we have answered research sub question SQ2: What are the requirements of prosumer communities for decision enhancement along their growth path? In the following chapter, the generic requirements will be used to design a solution for prosumer community decision enhancement.

4.4 Summary

In this chapter we used the analytical-evaluative framework of Forrest & Wiek (2014) to analyse the exploratory case studies. We identified various activities that the prosumer communities had in common, determined the sequence of events, their outcomes, and which decisions were involved, as well as the various actors that were associated in the value network. Based on this analysis, we identified the various life cycle phases of the growth path of prosumer communities: start-up, emerging growth, maturity, and decline or revival phase. This answers our research sub question RQ1. We also observed that prosumer communities are still in the emerging growth phase, although the first cautious steps are taken into the phase towards maturity. Along this road, many bumps and potholes were encountered by prosumer communities, and as they advance no smooth surface could be expected. An answer to research sub question RQ2 was provided by identifying which generic requirements have to be taken into account when designing a solution for enhancing decision making for prosumer communities.

5 Design of the prosumer community shopping mall

This chapter describes the design of the prosumer community shopping mall as an artefact that enhances decision making for prosumer communities.

5.1 Design approach

According to Sol (1991) "the realisation of information systems that support decision processes puts specific demands on methodologies and tools." To find a solution for prosumer community decision enhancement, we follow the design approach based on 'the way of' framework (Seligman et al, 1989; Sol, 1988), which is shown in Figure 10. *The way of thinking* describes the underlying design philosophy, while *the way of controlling* articulates the managerial aspects of the design process. *The way of working* denotes the steps and tasks that are followed in using the solution as a decision enhancement environment. The modelling concepts and notations that are being used are described by *the way of modelling*. Each component of the framework is further detailed in the following sections.

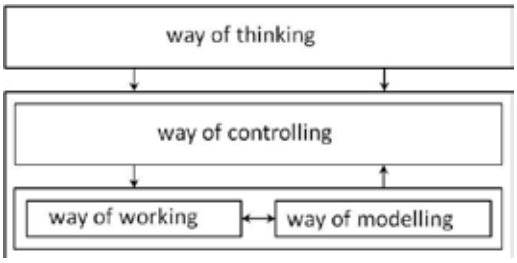


Figure 10: Framework for design approaches (Sol, 1988)

5.2 Way of thinking

The way of thinking incorporates the concepts and theoretical foundations underlying the solution, i.e. the facilitation of decision enhancement for prosumer communities along their growth path. To find a solution for the identified design issues, we followed a creative and abductive process. The line of reasoning followed starts with the notion that prosumer communities, in their search process for solutions, show *shopping behaviour*. Prosumer communities, as bottom-up initiatives, highly value their independency and autonomy, and attach great importance to freedom of choice. They are looking for information, tools, experience and expertise that can help them

forward. Collected information is compared and judged, and when necessary external experts are consulted for advice, before decisions and choices are made. Advice, guidance and support in their search process are appreciated, where trust plays an important role.

The shopping mall concept

Over the years, the concept of a studio, as an environment for decision enhancement, has been applied in several domains. A studio consists of guidelines and suites, which are packed with services (Keen & Sol, 2008). In the context of prosumer communities, it is then appropriate to look upon a suite as *a shop*. A shop contains a rich and flexible assortment of items, where the items can be examined and compared. The shopkeeper can provide advice, in doing so expressing guidelines for decision enhancement. The studio, as a collection of suites, then becomes equivalent to *a shopping mall*.
In a shopping mall multiple shops are collected under one roof, where customers and suppliers of services are brought together. The shopping mall offers structure by organising shops in different departments, and it offers overview and guidance by providing information desks and mall plans. Shopping in a mall means freedom of choice from a broad selection of products and services, next to the availability of guidance and advice. Furthermore, a shopping mall offers extra value-added services for socialising. We will use *the shopping mall concept* as a metaphor for the development of the design artefact.

The prosumer community shopping mall, based on the studio approach of Keen & Sol (2008), addresses the decision challenges that prosumer communities are facing. The shopping mall fuses the three main elements in decision making: *people, process* and *technology*.

People make decisions which are based on their skills, values, judgement and previous experiences (Keen & Sol, 2008). The shopping mall brings together the various people, or actors, that are involved in the decision processes of prosumer communities. The main stakeholders are the people that are acting at the organisational level of the community (i.e. community managers), next to the community members that have a say in the community. Both can be referred to as *service users*. Community managers have to make decisions at strategic, tactical and operational level within the prosumer community. Community members have to decide what facilitative tools they need to manage and control their energy behaviour within their own premises. Other involved stakeholders are, amongst others, local authorities, grid operators, energy retailers, installation companies and intermediary organisations (see also Section 4.1.5). These stakeholders can be regarded as potential *service*

providers. Furthermore, the *service facilitator* of the shopping mall plays an important role as provider of the service platform and as provider of the facilities for both the service users and service providers. The various actors related to the prosumer community shopping mall are further described in Table 10 below.

Table 10: Actors in the prosumer community shopping mall

Actor	Role	Example
Service user	- Responsible for the daily operation of a prosumer community - Responsible for energy management in own premises	- Prosumer community manager - Prosumer community member
Service provider	- Provide services for setting up a legal entity - Provide services for energy management	- Notary office - IT company - Retailer - Grid operator
Service facilitator	- Provide services and facilities to operate the shopping mall	- Mall facilitator

The decision *process* influences the likelihood of actors to make effective decisions (Keen & Sol, 2008). In their growth path from idea towards realising a full-grown, self-supportive prosumer community, people constantly are looking for information, knowledge and expertise that can help them forward. In this line of thinking a possible solution to facilitate this search process is to collect all the elements needed for decision making in an information system, and offer it in one place and make it accessible for all prosumer communities in the form of a shopping mall. The shopping mall offers tools and services that facilitate the decision process, such as directory services, profile management services and recommendation services.

According to Keen & Sol (ibid) *technology* could provide multiple types and levels of support to both people and process for making decisions. The decision enhancement services in the shopping mall provide support for the three growth path phases of prosumer communities. For the start-up phase, when the idea of establishing a local energy initiative is worked out, the shopping mall provides a large collection of information services on all kinds of things that enter into starting an initiative, such as legal constructions,

business models, financing, and energy technologies. For the emerging growth phase services and tools are provided that support the activities to further build-out the community, such as member recruitment, organising working groups, organising energy supply and realising energy projects and related energy technologies. For the maturity phase specific smart grid technologies and smart energy tools and services are provided that assist in operating the energy balance at the level of the prosumer community, as well as in the members' premises. Examples are asset management, billing services, energy monitoring and energy control services. The tools and services provide guidance and advice, thus facilitating service users in their decision process.

5.3 Way of controlling

According to Sol (1988) the way of controlling describes the managerial aspects of the measures and methods that are taken, in order to guarantee the quality of the end product. For prosumer communities, governance instruments should be available that adequately fit to the specific life cycle phase (Lattemann & Stieglitz, 2005). In the start-up phase the organisational structure is informal and communication is mostly one-on-one based on trust. The relatively small number of participants are intrinsically highly motivated, so there is no need for active control and management instruments. In the growth phase the number of participants increases, inducing a higher need for a structure and coordination mechanism. The core group apply themselves more and more on management and coordination tasks. Tools and instruments are needed to manage the organisational resources of volunteers and specialised working groups, however too many rules and control must be avoided in order to prevent loss of intrinsic motivation of participants. The maturity phase is characterised by a large number of participants with a high degree of specialisation and professionalization within the organisational structure. Governance tools should provide support for project management and financial resources, as well as tools for cooperation with the various stakeholders. Transparency and open communication toward members is important in order to appeal to a feeling of community.

5.4 Way of working

The way of working relates to the specification of tasks and processes that are involved in using the shopping mall as a decision enhancement environment. Based on the previous observations, the various tasks and processes involved in using the shopping mall, are described in Table 11, as well as which

functionalities are covered. The shopping mall is divided into two separate departments, one for each service user group: the community manager department and the community member department. The service providers have access to the shopping mall back office via the service creation dashboard.

Table 11: Prosumer community shopping mall tasks and processes and their functionalities

Shopping mall tasks and processes	**Functionalities**
Administration	
User registration	- User registration on first use. Three different roles: community manager, community member, and service provider
Access control	- Log in provides access to the related shopping mall department: community manager, community member, service creation
Profile management	- Creation and management of service user's profile
Dashboard	
Mall plan	- Provide overview of available shops
Service recommendations	- Recommend specific services based on the service user's profile and on the profile of other service users.
Service management	- Provide selection and payment of services (shopping cart, on-line payment) - Provide overview of previously acquired services
Shops	
Community manager department	- Provide access to the various shops ° Start-up support ° CRM support ° Energy projects ° Energy monitoring ° Energy control ° Maintenance ° Billing
Community member department	- Provide access to the various shops ° Energy monitoring ° Smart appliances ° Energy exchange ° My bill ° My community ° Support ° Home control
Service creation	- Provide access for service providers to the service creation dashboard

Administration covers all tasks and processes that are involved in the registration, authentication and profile management activities of the shopping mall users. The dashboard tasks and processes relate to the selection and the provision of overview of the available tools and service offering to the shopping mall users. The shops provide access to the underlying tools and services that advice and guide both community managers and community members in making decisions. Finally, service creation facilitates service providers in creating and deploying services.

5.5 Way of modelling

The way of modelling encompasses the models and modelling techniques that are used to specify and visualise the process steps and data flows of the various components within the shopping mall. These schematic specifications form the basis for the prototype implementation of the shopping mall. The Unified Modelling Language (UML) was used to model the decision enhancement processes in the shopping mall. UML uses a diagram notation for system modelling with the use of object-oriented concepts. Activity diagrams graphically represent the workflows that are related to the decision processes when working with the shopping mall. A use case diagram is used to depict the actors and their role in the prosumer community shopping mall (see Figure 11). Four roles can be distinguished: community manager, community member, service provider and mall facilitator. Furthermore, the use case diagram shows five different processes that are related to the shopping mall. These processes are further described in activity diagrams, later on.

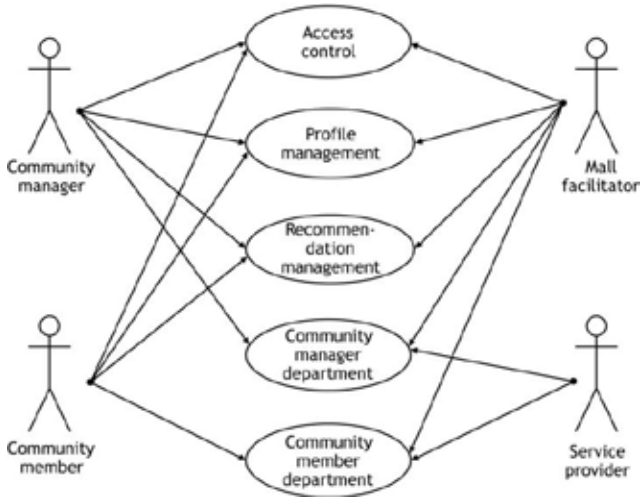


Figure 11: Prosumer community shopping mall use case diagram

Access control

Access control is needed to identify the various roles of the mall users, in order to provide access to a specific segment of the shopping mall. Community managers and community members have access to a different mall segment (i.e. shopping mall department), because the service offering to community managers, who operate at an operational level of the community, differs from the service offering to community members. Service providers get access to the back office of the shopping mall for service creation and service management purposes. Figure 12 shows the activity diagram of the access control process.

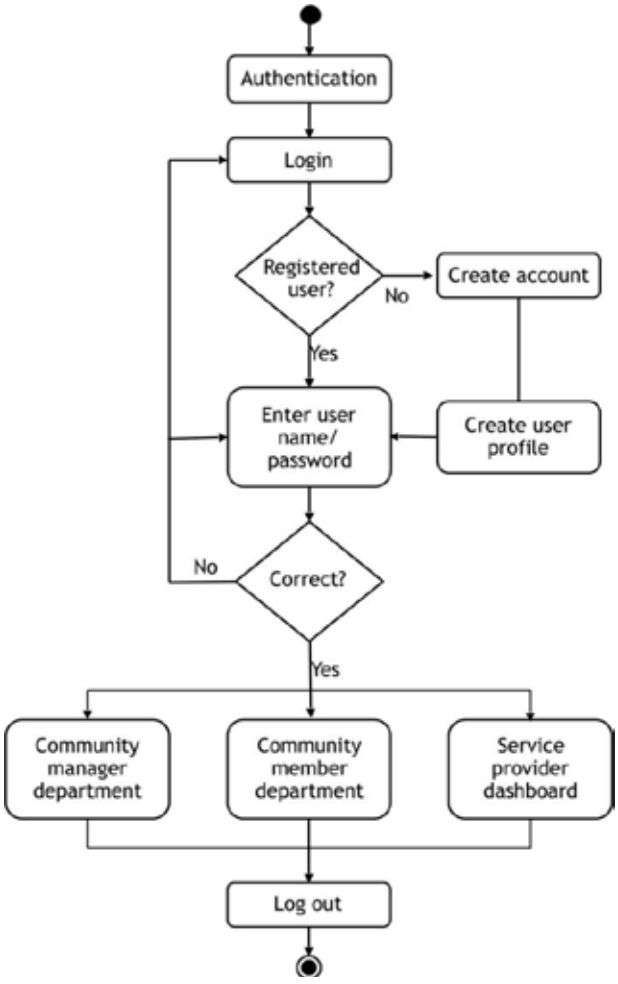


Figure 12: Activity diagram of the shopping mall access control process

When service users enter the shopping mall for the first time, they have to register, whereupon an account is created, next to a user profile (see also Profile management, described below).

Profile management

The main purpose of the shopping mall is to assist prosumer communities and their participants in finding information, expertise and tools and facilitate them in making decisions. Therefore, for each service user (i.e. community manager and community member) a user profile is being made. The profile management process is depicted in Figure 13. As described above, on the first time visit to the shopping mall, the service user has to register to create an account, and at the same time a user profile is created. Every time the user visits the shopping mall, his user profile is updated with his shopping history. The user profile's shopping history gives an indication of which life cycle phase the service user is in, serving as a basis for giving advice and guidance in the decision process.

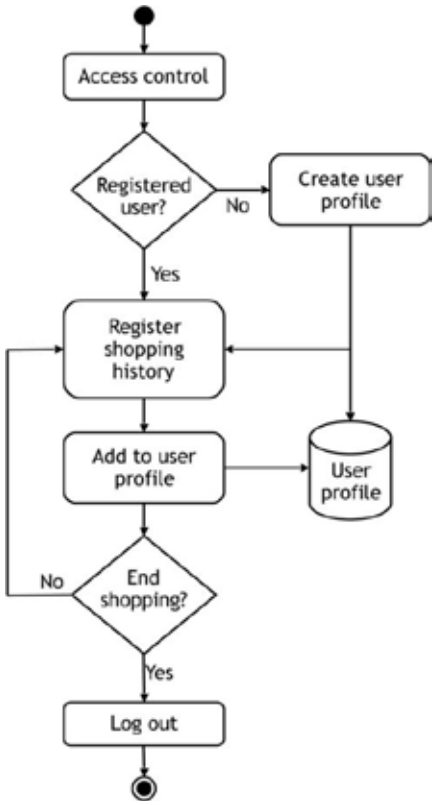


Figure 13: Activity diagram of the profile management process

Recommendation management

The user profile forms the basis for compiling service recommendations that are presented to the service user. The shopping history of other service users with a similar user profile are being used to select and present services that might be of interest to the service user. The service recommendations intend to guide the service user in making decisions which next step(s) to take. The recommendations management process is depicted in Figure 14.

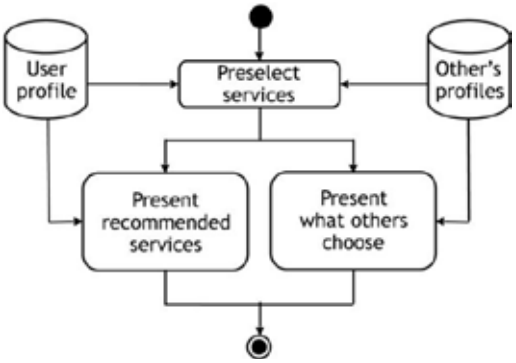


Figure 14: Activity diagram of the recommendation management process

Community manager department

The community manager department represents the decision enhancement services environment for the people within the prosumer community who operate at an organisational level. The community manager department shopping process is depicted in Figure 15. When access to the manager department is provided, the user profile is consulted to check if this is the first time visit. If so, the manager is directed to the start-up support environment, assuming that the prosumer community is still in the start-up phase. The start-up support environment offers information, tools and advice on all matters involved in setting-up a prosumer community.

If it is not the first visit, the community manager is guided to the mall plan that presents an overview of the available shops (i.e. directory service). Furthermore, recommended services are presented, which are based on the user's profile and on that of others with a similar user profile. In one shopping session various shops can be visited, where services can be viewed and selected (i.e. added to the shopping cart). The session is concluded by settling the bill at the central cash register and adding the selected services to the service user's environment (i.e. MyDashboard).

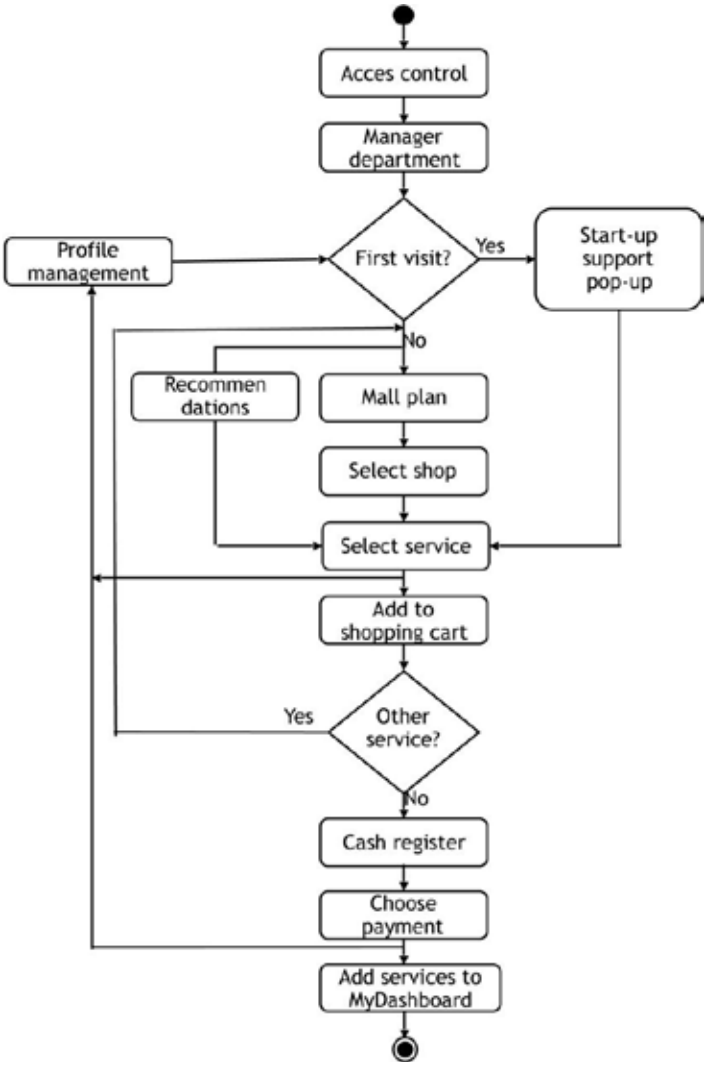


Figure 15: Activity diagram of the community manager department shopping process

Community member department

The community member department shopping process, as depicted in Figure 16, is for the greater part similar to the community manager department process. The main differences are the absence of the start-up support process, next to the content of the shops, because different tools and services are being offered to community members than to community managers.

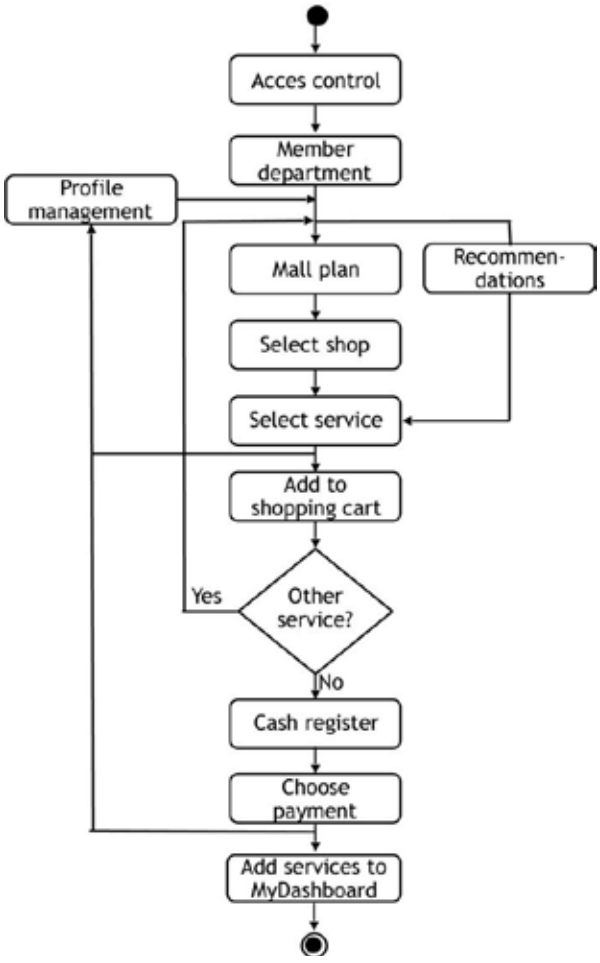


Figure 16: Activity diagram of the community member department shopping process

Service creation dashboard

At the back-end of the shopping mall, tools and services are being provided and exposed in the various shops by a variety of service providers. In order to guarantee a certain level of quality, next to interoperability, the offered tools and services need to comply to guidelines and standards that are imposed to service providers by the mall facilitator. The mall facilitator offers standard building blocks (e.g. customer registration, access control, service usage registration, billing, security, etc.) that can be used by service providers for service composition. Furthermore, guidelines are provided how building blocks can be used, which standards have to be employed, and how the service upload process has to be carried out. Before services are uploaded to the shopping mall, it is ensured that they comply to the provided guidelines

and standards. When the service fails the test, the service provider has to withdraw the service, or adapt the service and offer it for approval again. The service creation process is depicted in Figure 17. Whenever new services are uploaded to the shopping mall that fit to their user profile, service users receive a notification.

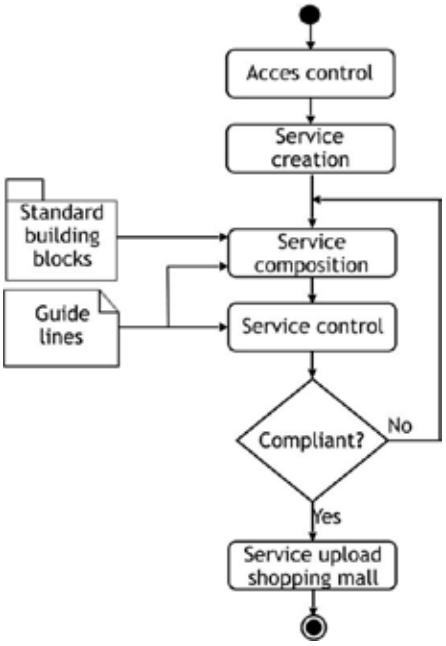


Figure 17: Activity diagram of the service creation process

5.6 Requirements check

In section 4.3 we identified the prosumer communities' requirements for decision enhancement. In section 5.1 we introduced the prosumer community shopping mall as an integrated full-service environment, which represents an online portal providing a broad collection of prosumer community related tools and services. As a next step we want to check whether the shopping mall satisfies the list of requirements.

R1. ***Guidance:*** *the solution must provide guidance to prosumer communities in finding the right information and expertise.*

The shopping mall provides guidance to service users in multiple ways. First, the floorplan shows an overview of the shops and the available tools and services for each shop, which helps them in finding what they need. Secondly, the customer's profile is used for preselecting services and tools that fit to the

recorded preferences in the user profile, as well as to the registered customer's shopping history. Thirdly, recommendations on potentially interesting services and tools are presented, based on the shopping history of other customers with a similar profile.

R2. Information access in one place: the information resources must be available, or at least accessible in one place.

The shopping mall, as an online portal with multiple shops, provides both service user groups access to a broad range of services and tools in one place (single point of access). As shopping mall customers they are offered a one-stop-shopping experience.

R3. Just in time information availability: the solution must present the information in sync with the needs and demands of the user.

Based on the customer's profile and that of others with a similar profile, services and tools are selected and presented that might be of interest to the customer, which fit to the momentary needs and demands of that moment.

R4. Location dependent information: information provided should be, when appropriate, locally or regionally demarcated.

The customer's profile contains address information, which can be used to preselect those services and tools that are location dependent (e.g. a list of available local installation companies).

R5. Ready-made versus custom-made: the solution must be adaptable to the specific needs of the local prosumer community.

The shopping mall is a generic solution, available for multiple prosumer communities. Based on his profile the service user is presented contextual information and services. This way each prosumer community will have its own virtualised personal shopping mall.

R6. Tool and service selection: the solution must provide a rich set of services and tools, which should be well-structured and organised in order to guide users in deciding on selection.

This requirement emphasises the key role of the mall facilitator as the selector and organiser of the service portfolio. The use of separate departments for each service user group, and the categorisation of services

and tools based on common functionalities into shops, provides this required structure. Furthermore, the mall floorplan serves as a service directory for the customers, where the content can be adapted to the customers' profile.

R7. Services for end-users: specific tools and services should be made available for individual prosumer community participants.

Because the shopping mall has a separate department for prosumer community members, this requirement is satisfied.

R8. Trustworthy solution provider: the party that provides the solution should be trustworthy, where users have the choice to decide on automatic control. Tools and services should be easy to use.

The shopping mall itself does not explicitly meet this requirement.

R9. Standardisation: standards should be used in order to guarantee interoperability and scalability of the solution.

The use of standard building blocks, in combination with the guidelines for implementation provided by the mall facilitator, should safeguard the interoperability of the services, as well as the scalability of the solution.

Resume

The shopping mall satisfies eight of the nine requirements that were formulated in Chapter 4. Only requirement R8, Trustworthy solution provider, is not explicitly met. This requirement can be set as a precondition for the successful operation of the shopping mall. After all, when prosumer communities do not trust the provider of the shopping mall, they will not use it. The *easy to use* requirement should be covered by applying usability standards when instantiating the shopping mall.

5.7 Resume of the shopping mall design

This chapter described the design of the shopping mall as an artefact that facilitates prosumer communities in enhancing their decision making. The 'way of' framework (Seligman et al, 1989; Sol, 1988) was used to articulate the design approach. An abductive line of reasoning was followed, leading to the construct of the shopping mall as a metaphor for the decision enhancement environment for prosumer communities (way of thinking), the various components of the decision enhancement environment (way of working), how this environment can be managed (way of controlling), and

which process steps and data flows are involved (way of modelling). The shopping mall satisfies eight of the nine specified requirements.

In the next chapter, the instantiation of the shopping mall is elaborated, which is later on used for evaluation purposes.

6 Instantiation of the prosumer community shopping mall

In this chapter we describe the instantiation of the prosumer community shopping mall in the form of a prototype. The prototype visualises and demonstrates the functionalities and the service offerings of the shopping mall.

6.1 The shopping mall prototype

Goal of the prototype

We developed a prototype as an instantiation of the generic prosumer community shopping mall that was introduced in Chapter 5. It demonstrates the functionalities and the various service categories that facilitate the decision enhancement of prosumer communities. The goal of the prototype is twofold. Firstly, we want to demonstrate our target group, prosumer communities, how the shopping mall works and can be used, and which services are being offered. Secondly, we want to evaluate the usefulness and usability of the shopping mall by using the prototype in a number of evaluation sessions. The evaluation process is described in Chapter 7.

Prototype implementation

The prototype is implemented using the software prototyping tool Axure RP©. The prototype is composed of a collection of static HTML pages where the users can click through (*Mall > Department > Shops > Services > Service description > Service selection*). The shopping mall departments, one for each service user group, are visualised as a collection of shops, where each shop, when clicked on, is presented on a separate page. Services in the shops are represented by icons, similar to apps in an app-store, and on mouse-over a short description of each service is shown. As in a real-life shopping mall, possibly multiple shops with a *competing* service offering (i.e. same service category) from different service providers are present, thus providing customers a wide assortment. The set of services that are demonstrated in the prototype is not exhaustive, but the list is representative for the services that came forward from the exploratory study (Chapter 2, 3 and 4). The prototype itself is not a fully implemented shopping mall; functionalities like selecting and uploading services are simulated through static HTML pages. Several services are linked through to actual websites.

Structure and content

The prototype has two main parts: a public accessible part and a password protected part. The public part consists of the shopping mall home page, which explains the purpose and the content of the mall, and a registration section where both prosumer community managers and members have to register and create an account in order to get access to the password protected part. Figure 18 shows a screenshot of the home page of the shopping mall prototype.

The password protected part of the shopping mall is build up from three different sections: the prosumer community manager department, the community member department, and one section for the service providers. Each of these sections is described in the Sections 6.2 until 6.4.

Figure 18: Screenshot of the home page of the prosumer community shopping mall prototype

A typical shopping session

Prosumer communities and their members come to the shopping mall in search for information, services or tools that they need for specific purposes. Before they can actually enter the shopping mall they first have to register and create an account. The registration information is used as the basis for a personal profile. After registration the user may, via the home page, log in to the shopping mall (see Figure 18). Depending on his profile he will enter the community manager department or the community member department. The department floorplan is shown, where he can select and enter a shop. When he clicks on one of the services in the shop, a service description is shown. Next, he can add the service to his shopping cart by clicking on the *Add to cart* button. Then he is asked whether he wants to continue shopping or if he wants to go the cash register for paying the bill. In one session several shops can be visited and multiple services can be selected. The shopping session is finished by checking out at the cash register, where the user can select the payment method. When the payment is settled then the acquired services are uploaded and installed on the user's personal system (e.g. PC, laptop) and removed from his shopping cart.

6.2 The community manager department

The community manager is the representative of the prosumer community's organisation. When the community manager has registered and created an account, he can log in via the home page to the community manager department. When he logs in for the first time, the system presumes that the community is in the start-up phase. Therefore, a pop-up screen is shown asking the manager if he wants to go to the start-up support shop, as shown in Figure 19. He can click on the pop-up and go to the start-up support shop directly. Otherwise, he can click away the pop-up.

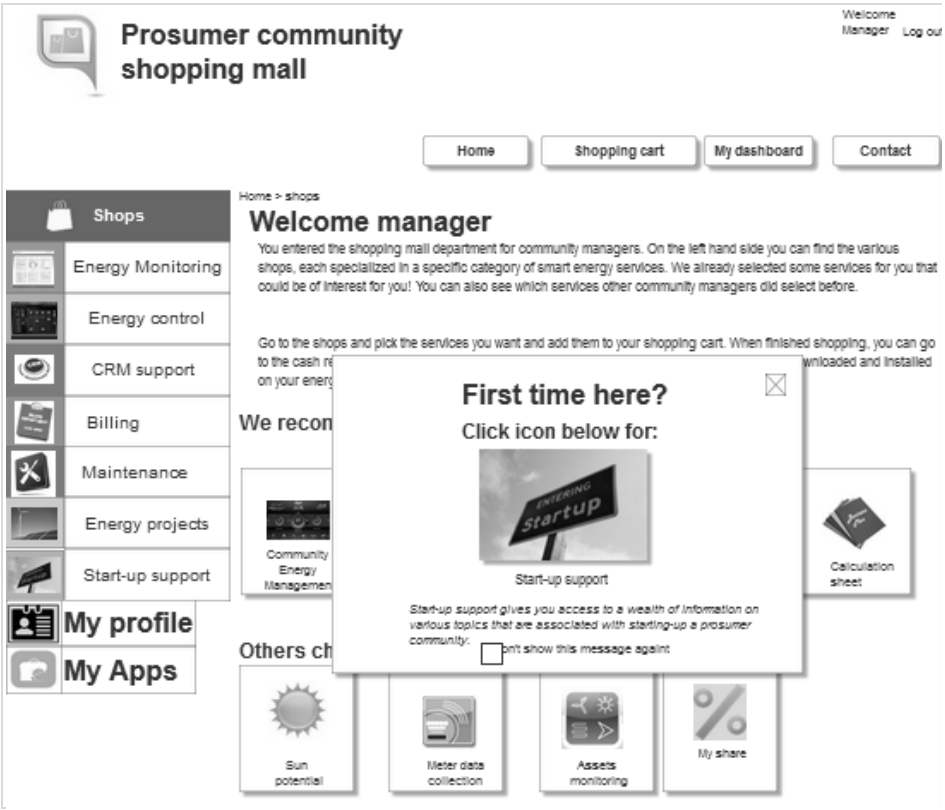


Figure 19: Screenshot of the community manager department

As shown in Figure 19, the community manager department is presented as a floorplan, which is composed of four different sections:

- **Navigation buttons:** Home, Shopping cart, My dashboard, Contact.
- **Main screen:** description of the department, recommended services and services that others chose.
- **Shops:** containing the shops Energy monitoring, Energy control, CRM support, Billing, Maintenance, Energy projects and Start-up support.
- **Personal:** My profile and My apps.

Each of the sections is described below.

Navigation buttons

The purpose of the navigation buttons is to provide easy navigation through the shopping mall.

- **Home:** leads the user back to the floorplan of the department.

- **Shopping cart:** leads the user to his shopping cart. The shopping cart shows the services that were selected in the shopping session so far. The available payment options are shown. Furthermore, the services that were purchased in earlier shopping sessions (*My downloaded apps*) are also shown on this page (see Figure 20).
- **My dashboard:** clicking on this button takes the user out of the department and the shopping mall into his own system (e.g. PC, laptop). There he finds the installed tools and services that were purchased before.
- **Contact:** this button is not implemented but it is supposed to link to the contact information of the shopping mall facilitator.

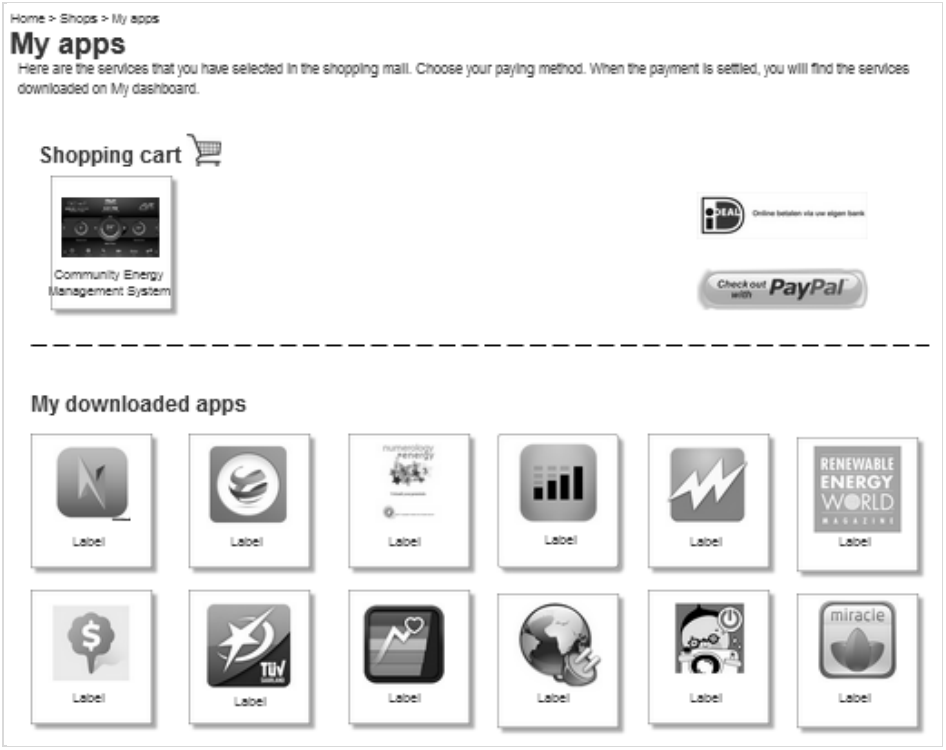


Figure 20: Screenshot of the shopping cart page

Main screen

The main screen shows a welcoming message, a description of the department, and a number of recommended services that are preselected for the community manager based on his personal profile. Optionally, also a number of other services are shown, which are selected based on the shopping history of other users with a similar profile.

Shops

In the community manager department the following shops can be found:

- **Energy monitoring:** in this shop various services are available that can be used to monitor the energy components and energy flows within the community. Examples services are Community Energy Management, Meter Data Collection, and Storage Monitoring.
- **Energy control:** the services in this shop are related to controlling and managing the energy streams within a community, such as Demand-Supply Forecast, Load Balancing, and Flexibility Aggregation.
- **CRM support:** CRM support services are aimed at managing and optimising the relation with members and customers. Services include Customer Administration, Customer Profile Management, and Customer Support.
- **Billing:** billing services are focused on collecting data for the billing process and the composition of the invoices. Services included are Meter Data Collection, Price Data Collection, and Energy Bill Generator.
- **Maintenance:** in the Maintenance shop services can be found that can be used for the maintenance of collective energy facilities (e.g. Asset Monitoring, Firmware Update).
- **Energy projects:** this shop is more information oriented. It provides access to relevant information and expertise on setting-up various prosumer community energy projects such as a PV park, wind mill(s), a biomass installation, or a collective heat system. For each form of energy project an extensive list of services is given that can be used for preparation and stepwise realisation of an energy project. Figure 21 shows an overview of part of the available services that can be used for setting-up a PV park.
- **Start-up support:** similar to the Energy projects shop, this shop is also information oriented. The services in this shop are subdivided in various categories, based on the steps that have to be taken to set-up a prosumer community. Figure 22 shows a screenshot of part of the services in the start-up support shop.

Personal

The personal section of the shop floorplan consists of two components:

- **My profile:** shows the personal profile of the user, including personal data, preference settings and the shopping history of the user.
- **My apps:** links to the same page as My shopping cart, showing the services that previously have been acquired.

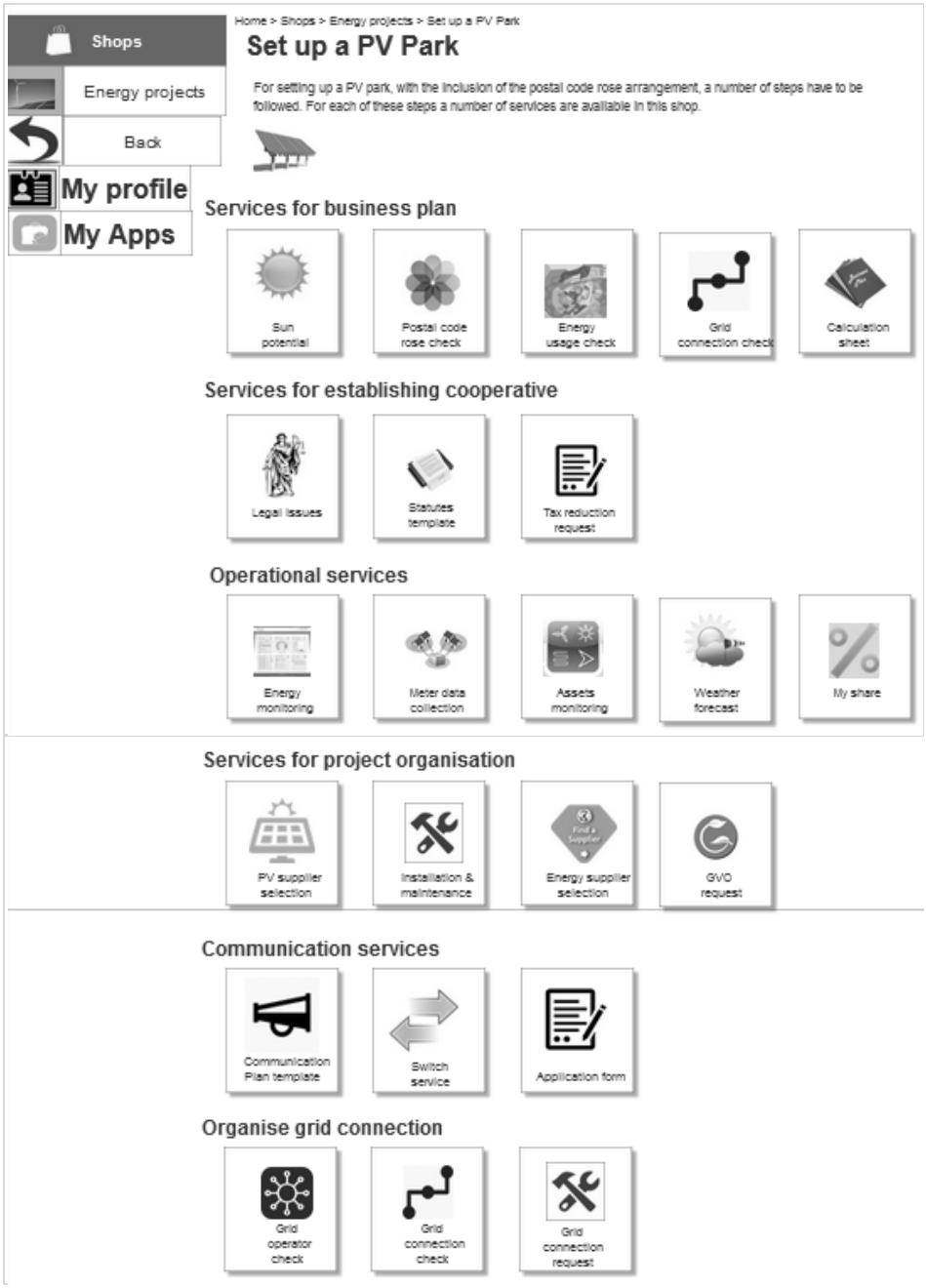


Figure 21: Screenshot of the services for setting-up a PV-park project

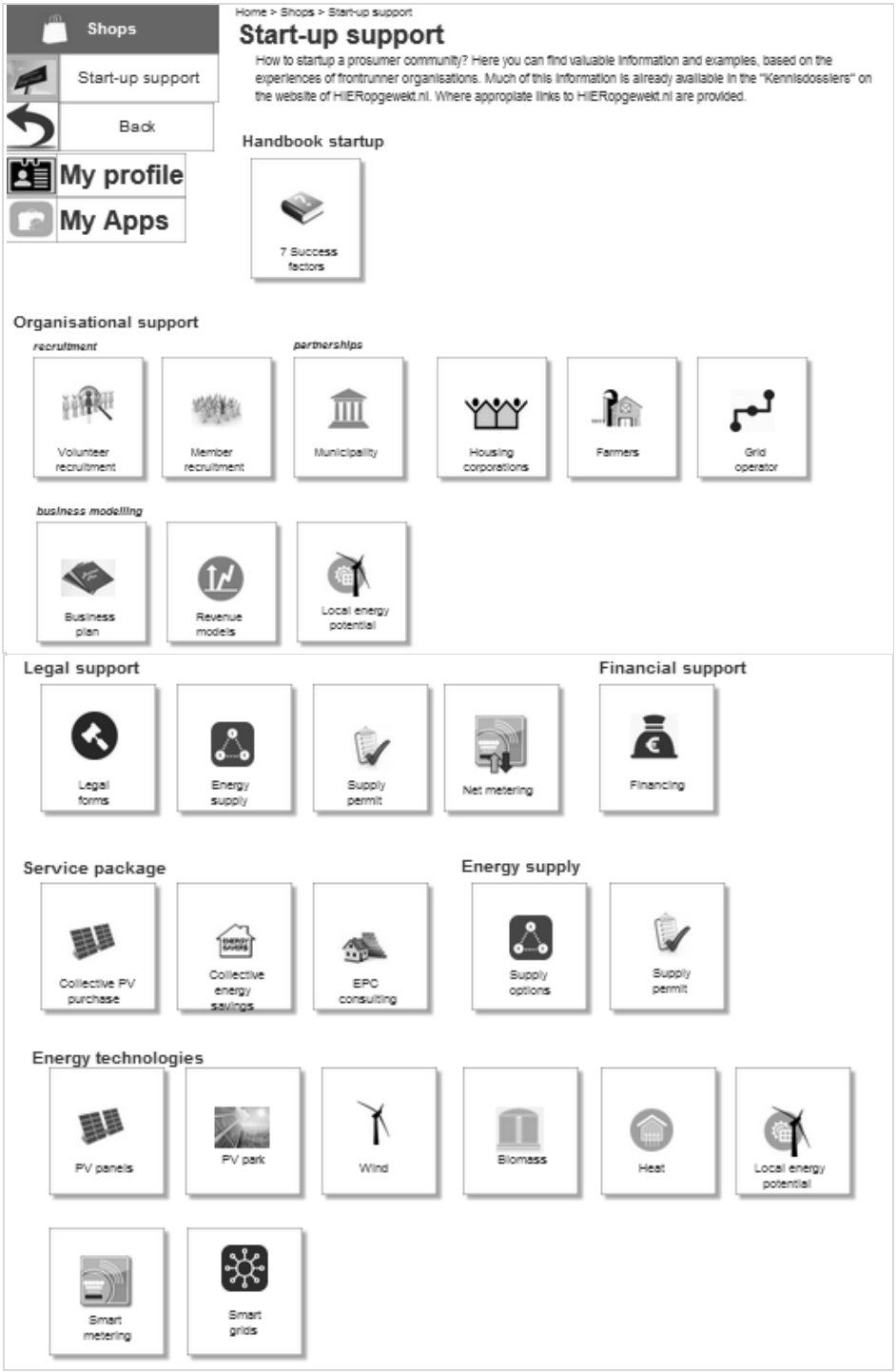


Figure 22: Screenshot of the services related to starting-up a prosumer community

6.3 The community member department

The mall floorplan layout of the community member department, as shown in Figure 23 below, is similar to the one of the community manager department, consisting of the sections Navigation buttons, Main screen, Shops, and Personal. Below, we only describe the Shops section, because this is the only part that is essentially different with respect to the content.

Figure 23: Screenshot of the community member department

Shops

In the community member department the following shops can be found:

- **Energy monitoring:** this shop offers services that provide users insight in the energy streams within their premises. Example services are Home Energy Management, My Energy Usage, My Energy Production, and My Energy Storage.
- **Smart appliances:** this shop offers services for connecting smart home appliances, such as washing machine and dish washer, to the Home Energy Management System (HEMS). This way, the appliances can be scheduled for operation from the central control unit.
- **Energy exchange:** the services in this shop provide the users with the means to choose what they want to do with their self-generated energy: use it for own consumption, trade it with others, donate it to someone else, or to outsource energy control to a third party. Example services include My Energy First, My Energy Trade, and Donate My Energy.
- **My bill:** this shop offers services that enable users to monitor and control their energy budget, preferences settings and notifications. Example services are My Online Bill, My Energy Budget, and Budget Warning.
- **My community:** these services provide users with the means to share and exchange information with others within the community and benchmark their energy patterns. Example services are Meet & Greet, Share Tips & Links, Benchmarking, and Energy Game.
- **Support:** the services in this shop give users access to various support resources. Example services include Support Centre, Self Service, FAQ, and Share Tips & Tricks.
- **Home control:** this shop offers services that are not directly energy related. These smart home services can be integrated with the smart energy services offering. Services include Home Security, Air Control Quality, and Blinds & Shutters.

6.4 The service provider dashboard

The service provider section is added to the prototype with the purpose to illustrate the effect of adding new services to the shopping mall. The user has to login on the home page as service provider, which then shows him the service creation dashboard (Figure 24).

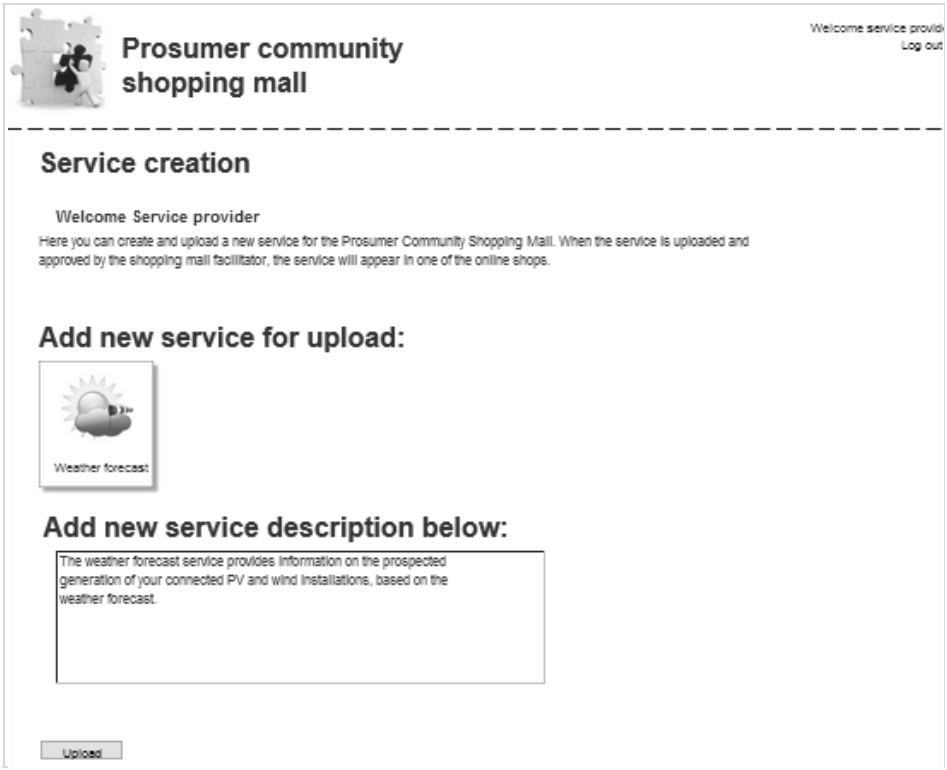


Figure 24: Screenshot of the service provider dashboard

The service creation process is represented in a rather simplified way. The service icon of the new service and the service description are already filled in. Furthermore, the verification process of the mall facilitator is faked. The service provider only has to click on the *Upload* button, after which a pop-up message is shown that the mall facilitator has approved the service and that the service is successfully uploaded to the shopping mall. In the evaluation session scenario, which is described in Chapter 7, the service creation process is used to illustrate the dynamics of the shopping mall: the continuously renewal and extension of the service portfolio. Whenever a service provider adds a new service to the shopping mall, then customers with a matching profile will receive a notification.

6.5 Summary

In this chapter we described a prototype as an instantiation of the prosumer community shopping mall, which was presented in Chapter 5. The prototype visualises and demonstrates the generic services (e.g. directory, profile management) of the shopping mall and the various service categories (e.g. information, monitoring, control) that enhance decisions by prosumer communities. The shops in the two different departments of the shopping mall offer a broad palette of tools and services for both prosumer communities and community members. The prototype also demonstrates the process of service renewal. The prototype provides an additional answer to the research sub question SQ3 of how a solution looks like that meets the requirements for decision enhancement for prosumer communities.

The following chapter describes the shopping mall evaluation process, where we used the prototype to demonstrate the shopping mall functionalities and its service offering.

7 Evaluation

This chapter describes the results of the evaluation sessions. The main objective of the sessions was to evaluate the perceived usefulness and perceived usability of the shopping mall for enhancing the decisions of prosumer communities. Three group evaluation sessions with prosumer communities were performed, next to eight individual evaluation sessions with energy experts. First, the evaluation approach, the structure of the sessions, and the processing of the results are elaborated, followed by a detailed description of each of the evaluation sessions and their results. The results of the usability aspects are described separately.

7.1 Evaluation approach

We developed the prosumer community shopping mall as a generic solution for enhancing the decision making process of prosumer communities in the various phases of their growth path. We implemented the prototype, as an instantiation of the shopping mall, to demonstrate the shopping mall´s functionalities and its service offering. The prototype was submitted for evaluation purposes to a number of prosumer communities and energy experts.

In design science the solution to a real world problem is a design, and there are usually many different solutions. These solutions are evaluated by their utility with respect to the stakeholder goals, and there is not one single best solution (Wieringa, 2014). According to Keen & Sol (2008) effective decision enhancement rests on the three U's of *usefulness*, *usability* and *usage* (ibid p.39). In the evaluation process we asked the participants to evaluate the prototype on the level of *the generic solution,* i.e. the shopping mall, and not its *instantiation*, the implemented prototype. Therefore, in the context of this research, we mean with usefulness and usability the *perceived usefulness* and *perceived usability*. Usefulness is defined as to what extent the shopping mall is useful (i.e. is beneficial, provides added value) for enhancing the decisions of prosumer communities in the start-up phase, the emerging growth phase and the maturity phase, and in the daily operational support of prosumer communities. Usability is defined as the extent to which the shopping mall, with its generic functionalities and service offerings, is easy to use.

Selection of prosumer communities for evaluation sessions

Various prosumer communities from the network of the researcher were approached, and eventually three initiatives were available for an evaluation session: AmersVolt, Eemstroom and Groninger Energie Koepel (GrEK)[31]. It was explicitly chosen not to approach the initiatives that had been involved in the exploratory case studies in order to prevent any form of bias. Table 12 gives an overview of the group evaluation sessions.

Table 12: Overview of the group evaluation sessions with prosumer communities

Group evaluation sessions	**Number of participants**	**Session date**
Amersvolt	5	13-10-2014
Eemstroom	5	14-10-2014
Groninger Energie Koepel (GrEK)	7	28-11-2014

Selection of experts for evaluation sessions

For the expert evaluation sessions we wanted to select a group of professionals, representing a broad selection of the energy sector, who were in some form involved with prosumer communities. In the end, eight experts participated, each in an individual evaluation session. Table 13 below gives an overview of the expert sessions.

Table 13: Overview of the expert evaluation session

Expert	**Organisation and affiliation with prosumer communities**	**Session date**
Program manager	Alliander - Grid operator - Facilitates prosumer communities	22-09-2014
Senior principal consultant	DNV GL – Energy research and consultancy - Innovation projects on smart grids development	06-10-2014
Consultant	Self-employed - Program manager smart grids for grid operator	08-10-2014
Project advisor	RVO – Dutch Enterprise Agency - Coordinator and advisor of subsidiary program for smart grid pilot projects	13-10-2014
Project manager	HIERopgewekt – Intermediate knowledge platform	14-10-2014

[31] In the GrEK session four different prosumer communities were represented.

Expert	Organisation and affiliation with prosumer communities	Session date
	- Coordinator of knowledge sharing platform for Dutch prosumer communities	
Consultant	Self-employed - Project manager energy projects - Director of a prosumer community	7-11-2014
Consultant	TKI SWITCH2SmartGrids - Former CEO of IBM Benelux (retired) - Advisor and assessor of smart grid pilot projects	24-11-2014
Entrepreneur	Shared Service Centre - Initiator and former director of a prosumer community - Board member of shared service centre for prosumer communities	7-01-2015

Pilot evaluation session

Prior to the sessions with the prosumer communities and experts, a pilot evaluation session was conducted with a number of students from the Hanze University of Applied Sciences Groningen. The objective of this pilot session was to verify whether the structure and content of the session were clear, consistent and understandable for the respondents, and whether the used instruments (presentation, task assignment form and questionnaire) would yield useful results. Based on the given feedback, only minor changes to the sessions' structure and content were made.

7.2 Structure of the evaluation sessions

For the evaluation sessions of both the prosumer community groups and the experts the same structure and procedure were followed. Each session consisted of four parts:

1. **Presentation:** after a short introduction round, the context of the research and the goal of the session was explained in a PowerPoint presentation.
2. **Demonstration:** the presentation was followed by a short demonstration of the shopping mall prototype, including the instructions on how the prototype should be used during the task assignment.

3. **Task assignment:** assignment forms were handed out to the participants. Next, the respondents started to work with the prototype, where they followed the instructions of the task assignment form. The content of the task assignment form is described in more detail in the section below. The complete task assignment form is listed in Appendix 5.
4. **Questionnaire:** after the task assignment was finished, the participants were invited to fill in the questionnaire. The content of the questionnaire is described in more detail in the section below. The complete questionnaire can be found in Appendix 6.

During the sessions there was ample room for discussion, from which some results are included in the evaluation results as anecdotal evidence. Each of the sessions was audio recorded, and worked out in separate reports (Timmerman, 2015).

Task assignment form

After the introductory presentation and the short prototype demonstration, the participants were invited to start to work with the prototype. They received an assignment form, describing the various tasks they had to perform (see Appendix 5). The task descriptions on the form served as a guidance map for walking the respondents step by step through the various parts of the shopping mall prototype. During the session they had to switch roles a number of times by logging in as a community manager, as a community member or as a service provider. The objective of this exercise was to give the respondent insight and understanding of the shopping mall, next to demonstrating the functionalities that are offered by the shopping mall.

Table 14 below shows the various tasks of the assignment form and its intended purpose(s). Each task relates to one or more specific functionalities of the shopping mall, illustrating its added value, meaning: enhancing the respondent in his decision making process.

Table 14: Overview of tasks on task assignment form

Task	**Intended purpose(s)**
General	
Account registration	- Demonstrate that different roles (manager, member) give access to different shopping mall departments

Task	Intended purpose(s)
Manager role	
Find information and services for starting up a prosumer community	- Demonstrate structure and navigation of shopping mall - Demonstrate complexity of starting-up a prosumer community - Demonstrate profile-based service offering (e.g. on first login the start-up support pops up) - Demonstrate available services for starting up a prosumer community
Find and select Community Energy Management System	- Demonstrate structure and navigation of shopping mall - Demonstrate richness of available services - Demonstrate guidance in shopping process
Find and select information and services for setting up a local PV park	- Demonstrate structure and navigation of shopping mall (all services in one place) - Show complexity of realising a local energy project - Demonstrate structured service offering of shopping mall (e.g. location based service selection)
Member role	
Log in	- Demonstrate difference between manager and member department
Find and select different services for monitoring and controlling in-home energy streams and appliances	- Demonstrate structure and navigation of shopping mall - Demonstrate richness of available services - Demonstrate guidance in shopping process
Profile based service recommendation	- Demonstrate service recommendation based on personal user profile and shopping history
Bill payment	- Demonstrate one-stop-shopping experience - Demonstrate service upload and installation to user's environment

Task	Intended purpose(s)
Service provider role	
Add a new service	- Demonstrate dynamic character of shopping mall - Demonstrate continuous renewal of service portfolio

The questionnaire

After finishing the task assignment with the shopping mall prototype, each participant was requested to fill in the questionnaire. The objective of the questionnaire was to evaluate how the respondents perceived *the usefulness and usability* of the generic concept of *the shopping mall*. We included a separate part in the questionnaire for the evaluation of *the usability of the prototype*.

The questionnaire consisted of a quantitative (i.e. statements) and qualitative (i.e. open questions) part, which are described below separately. The last part of the questionnaire was used for the collection of personal data of the respondent such as age, gender, education, and prosumer community involvement. The complete questionnaire is listed in Appendix 6.

Statements on usefulness, usability and session facilitation

The quantitative part of the questionnaire consisted of twenty statements, where each statement could be scored on a five point Likert scale (Jamieson, 2004). The score range was:

1 Strongly disagree
2 Disagree
3 Neutral
4 Agree
5 Strongly agree

Seventeen statements were positively formulated, while three statements were formulated in a negative way. The quantitative part was composed of three different segments: eleven statements covering the usefulness of the shopping mall; six statements concerning the usability of the shopping mall prototype; and three statements relating to the quality of the session facilitation.

The usefulness statements were related to the main functionalities that are facilitated by the shopping mall for enhancing the decision making process, as listed below:

- *Facilitate the start-up phase*
  - Provide services for starting up an initiative
  - Achieve added value for the start-up phase
- *Facilitate the emerging growth phase*
  - Provide services for realizing local energy supply
  - Provide services for setting up a local energy project
  - Provide services for member and customer recruitment
  - Achieve added value for the emerging growth phase
- *Facilitate the maturity phase*
  - Provide services for the daily operational activities
  - Provide services for local balancing of demand and supply
- *General facilitation*
  - Acknowledge the role of the mall facilitator
  - Provide services for individual community members
  - Achieve insight in current and future service offerings

The usability statements were related to the evaluation of the interface and the various user interaction elements of the prototype:

- Clarity and logic of the structure
- Visual attractiveness of the interface
- Clarity and ease-of-use of the interface
- Easiness of navigation
- Understand ability of the used terminology
- Adequacy of feedback during navigation

The last quantitative part of the questionnaire consisted of three statements for evaluation of the session facilitation:

- Formulation and feasibility of task assignment
- Clarity on up-font expectations
- Adequate room for personal contribution

Open questions on usefulness

Seven open questions were included in the questionnaire for collecting additional qualitative evaluation information on the perceived usefulness of the shopping mall, supplementary to the quantitative part. Respondents could give their top 3 ranking, choosing out of 8 options, of what they considered to be the most valuable functionalities of the shopping mall. Furthermore, they could state under which preconditions prosumer communities would be

willing to make use of the shopping mall. They could also give their opinion on their perceived added value of the shopping mall, next to what they considered to be the strong and weak aspects, and which elements they thought were still missing. Finally, they could write down whatever they thought was left unsaid, in order to identify items that could further improve the usefulness of the shopping mall.

7.3 Processing of the data

When the evaluation sessions were completed, the results of the questionnaires were processed in IBM© SPSS© Statistics. We used four different sets of data: three sets for each of the prosumer community sessions, and one set for the collective data of the eight expert evaluation sessions. The total sample size of all the sessions together is 25 (17 from the prosumer community evaluation sessions; 8 from the individual expert evaluation sessions). All Likert scale statements were coded in an SPSS variable sheet. For each of the sessions' data sets the mean (μ), the standard deviation (σ), and the Mode (M) were calculated for each statement. The same analysis was carried out for the collective results of all the sessions.

The Sections 7.4 up to 7.7 below describe for each separate evaluation session the proceedings, the usefulness evaluation results that came forward, and the analysis of these results. In a separate section (7.8) the usefulness results of all the sessions together are elaborated. The results of the usability evaluation of all the sessions together are described in the last section (7.9).

Criterion for statement acceptance

The calculated mean (μ), standard deviation (σ), and Mode (M) of each statement are used to determine whether there is general consensus amongst the respondents. Whenever the mean of a statement is scored higher than 3,5 ($\mu > 3{,}5$ – agree and strongly agree), the standard deviation is lower than 1 ($\sigma < 1$), and the Mode is equal or higher than 4 ($M \geq 4$), it is concluded that respondents agree and are positive on the statement. A standard deviation that is equal or higher than 1 ($\sigma \geq 1$), indicates that there is disagreement between the respondents on that specific statement.

7.4 Amersvolt community session

Amersvolt is a residents' collective, which organises projects with and for residents of the cities of Amersfoort and Utrecht. Their main goal is to stimulate energy savings. Amersvolt initiates and stimulates various energy related projects, often neighbourhood oriented, such as home insulation

programs and purchase advice on low-energy consuming home installations. They also act as middleman for collective purchase projects and for advice and information consultation. They claim that the success of Amersvolt is based on the dedication of their local ambassadors, who create a high level of commitment in their own neighbourhood. The basic principle of the Amersvolt collective is that the ownership of projects should be in the hands of the people themselves.

The session

The evaluation session was organised on a week-night with five volunteers of Amersvolt at the business premises of one of the participants. All of the participants were in their daily work technical related professionals.

During and after the introductory presentation, there already started a lively discussion about the phenomenon of prosumer communities, their goal settings and the way they are organised. Amersvolt explicitly choose not to set-up a legal entity of a cooperative, because in their opinion such a legal entity could be an obstacle for taking in a neutral position. Furthermore, they indicated that many of the initiatives focus too much on energy production, while Amersvolt's primary focus is on energy savings. The importance of a solid business case was also brought forward, but even more importantly, the essence of a social value case. When people can be convinced that the added value (both saved money, sustainability gains, and psychological values) outweighs the needed investments, they will be willing to participate. As one of the participants said: "You do not need to convince the 10 % of early adopters, but the 90% of smart followers and laggards."

Usefulness evaluation results

Table 15 shows the results of the usefulness statements. The results include the mean (μ), the standard deviation (σ), and mode (M). Five participants filled in the questionnaire.

Table 15: Results of usefulness statements Amersvolt session

Usefulness statements	**Scale**					**Amersvolt**		
Statement	**1**	**2**	**3**	**4**	**5**	**(N=5)**		
						μ	***σ***	***M***
Start-up phase								
1. The shopping mall provides relevant information and examples for starting-up a local energy initiative	0	0	1	3	1	4,0	,707	4

Usefulness statements	Scale					Amersvolt		
Statement	1	2	3	4	5	(N=5)		
						μ	*σ*	*M*
2. The shopping mall provides no added value for the start-up phase, while info also can be found elsewhere [a]	0	0	1	4	0	3,8	,447	4
Emerging growth phase								
3. The shopping mall provides support for the selection process of local energy supply	0	0	2	3	0	3,6	,548	4
4. The shopping mall provides support for setting-up a local energy project	0	0	1	4	0	3,8	,447	4
5. The shopping mall provides services for member and customer recruitment	0	1	1	2	1	3,6	1,14	4
6. The shopping mall provides no added value for the growth phase, because info also can be found elsewhere [a]	0	0	2	3	0	3,6	,548	4
Maturity phase								
7. The shopping mall provides services that are useful for the daily operation of a local energy initiative	0	1	1	2	1	3,6	1,14	4
8. The shopping mall provides useful services that support local balancing of energy demand and supply	0	0	2	2	1	3,8	,837	3[b]

Usefulness statements	Scale					Amersvolt		
Statement	1	2	3	4	5	(N=5)		
						μ	*σ*	*M*
In general								
9. Who fulfils the role of the shopping mall facilitator is of no importance for the local energy initiatives [a]	0	0	1	3[c]	1	4,0	,707	4
10. The shopping mall provides services that are useful for the individual participants of a local energy initiative	0	0	1	3	1	4,1	,548	4
11. The shopping mall provides insight in which services are available for local energy initiatives now and will be available in the future	0	2	1	2	0	3,1	,894	2[b]

a. Results have been recoded from negative to positive [32]
b. Multiple modes exist. The smallest value is shown
c. One score of 3,5 included

Table 16 shows the results of the open questions on usefulness of the Amersvolt session. The table summarizes what the respondents wrote down at the open questions with respect to the usefulness of the shopping mall. Similar answers are clustered as much as possible. The last column in the table shows how many respondents wrote down that answer.
At question 12 the respondents could give their top 3 ranking, choosing out of 8 options, of what they considered to be the most added value functionalities of the shopping mall. The three highest scoring functionalities are listed in the table. The ranking is based on the highest number of scores on priority number 1, followed the number of scores on respectively priority 2 and 3.

[32] The statements 2, 6 and 9 were formulated negatively. For analysis purposes the scores on these statements have been recoded. For instance the score 'Strongly agree (5)' has been recoded into 'Strongly disagree (1)'.

Table 16: Results of open questions Amersvolt session

Statement	Results Amersvolt	(N=5)
12. Top 3 of shopping mall's added value	1) All services in one place 2) Interoperability of services 3) Continuous renewal of service offering	5 3 2
Open questions	***Clustering of written quotations***	
13. Terms and conditions for acceptance to use the shopping mall	- Complete and diverse information, book of reference, package offering, easy product and service integration - Accessible, attractive, and easy navigation - Relief and professionalization - Own identity (personalisation) - No upfront obligations - Large reach	4 2 1 1 1 1
14. Added value for prosumer community	- All services in one place - Proven concept - Diversity and opportunity for own selection (recommendations) - The shopping mall is the place where you can find anything with a trustful brand - Interoperability (tested and approved)	4 1 1 1 1
15. Strong points of the shopping mall	- Large collection of information and services at one place - How others like a service (rating) - Classification of users and the services that are needed for that (personalisation and control) - Platform for new tools	5 1 1 1
16. Weak points of the shopping mall	- The shopping mall prototype could give more guidance during the navigation - How to distinguish between the potentially large amount of similar apps? - Lack of attention for social aspects (community)	4 1 1
17. Essential missing elements in the shopping mall	- Clear navigation structure and navigation guidance - Comparison and benchmarking	3 1
18. Other remarks	- The system should be open, not closed (why log in?) - I am very curious for the business case - I need to scroll a lot to get a good overview	

Usefulness evaluation analysis

The results, shown in Table 15, give a positive indication (i.e. high μ, low σ) on the usefulness of the shopping mall with respect to 'support in the start-up phase' (statement 1 and 2), '(4) support in setting-up a local energy project', and '(10) providing useful services for individual participants'. They also agree that '(9) it is important for prosumer communities who fulfils the role of the mall facilitator'. The scores are moderately positive on the usefulness of the shopping mall with respect to '(3) support for realizing local sustainable energy supply', '(6) the added value for the emerging growth phase', and '(8) support for local demand and supply balancing'. There is no agreement on the other three statements regarding the usefulness of the shopping mall.

Overall, it can be concluded that the Amersvolt respondents are positive to moderately positive on the usefulness of the shopping mall. For the start-up phase the scores are positive, for the emerging growth phase positive to moderately positive. For support in the maturity phase the scores are more moderate. The results of the open questions, as shown in Table 16, support the overall positive conclusion. This is illustrated by the quotation 'the large collection of information and services in one place', which is written down multiple times as considered to be the most added value and strongest point of the shopping mall. This is once more confirmed by the highest top 3 score on question 12 'all services in one place', followed by 'the interoperability of services'.

The main weak and missing points of the shopping mall are related to the usability aspects of the shopping mall prototype. This might indicate that the respondents had some difficulty in distinguishing between the *usefulness* evaluation of the *shopping mall artefact*, and the *usability* aspects of the *prototype,* although during the evaluation session the researcher repeatedly emphasized the difference.

With respect to terms and conditions for acceptance (question 13), the respondents listed the completeness, diversity, and ease of integration of the information and services provided as the main prerequisites. Furthermore, the respondents indicated that they consider usability aspects of the shopping mall as a priority ('accessibility', 'attractiveness', 'ease of navigation'). They also listed open access to the shopping mall as an important subject ('no upfront obligations', 'the system should be open, not closed'). The upfront registration process was implemented in the prototype, and apparently this is not desirable. As one of the respondents remarked: "Why do I have to register before I can enter the mall? First, I want to go inside and look around to know what is being offered. I only want to register when I am convinced that it provides added value."

During the session some participants mentioned the feasibility of a shopping mall implementation (e.g. investments needed, revenue model), and its technical complexity. As one of the respondents expressed it: “How do you make money with selling apps, while the investments for implementing a shopping mall will be substantial. Do prosumer communities have money to spend in the shopping mall?”
One of the respondents expressed his curiosity: “I would really be interested to look around when such a shopping mall would exist.”

7.5 Eemstroom community session

Eemstroom is a prosumer community for the city of Amersfoort and its surroundings. Sustainability is the basic principle of the cooperative, while their main goal is to provide 100% sustainable energy for their members, generated by own facilities. At this moment Eemstroom supplies sustainable energy (both gas and electricity) via a reseller construction. Furthermore, they act as an intermediate for collective projects such as collective purchase of solar panels and neighbourhood insulation programs. They are planning to realise a solar park in the vicinity of Amersfoort. The session took place at the office premises of one of the participants.

The session

Five people participated in the Eemstroom evaluation session, of which three respondents were directly involved in the Eemstroom prosumer community. The other two participants were indirectly involved as employees of an ICT company that develops services for, among others, prosumer communities.

During the introductory presentation the question was stated why the year 2007 seems to be pivotal in the emergence of Dutch prosumer communities. A number of reasons were brought forward, where the exemplary German Energie Wende and the developments in Denmark were seen as the main landmarks. These successful examples played a role in arousing the general discontent with the fact that the Netherlands was lagging behind in establishing short and long term sustainability goals. In particular, the role of the large incumbent energy companies (e.g. installing several new coal fired plants), and the lack of decisiveness shown by the Dutch authorities in accelerating the energy transition, were seen as incentives for people to take up local energy initiatives.

Usefulness evaluation results

Table 17 shows the results of the usefulness statements, based on the input of the five participants.

Table 17: Results of usefulness statements Eemstroom session

Usefulness statements	**Scale**					**Eemstroom**		
Statement	**1**	**2**	**3**	**4**	**5**	**(N=5)**		
						μ	***σ***	***M***
Start-up phase								
1. The shopping mall provides relevant information and examples for starting-up a local energy initiative	0	1	2	2	0	3,2	,837	3[b]
2. The shopping mall provides no added value for the start-up phase, while info also can be found elsewhere [a]	0	2	1	2	0	3,0	1,000	2[b]
Emerging growth phase								
3. The shopping mall provides support for the selection process of local energy supply	0	0	2	3	0	3,6	,548	4
4. The shopping mall provides support for setting-up a local energy project	0	0	0	5	0	4,0	,000	4
5. The shopping mall provides services for member and customer recruitment	0	2	2	1	0	2,8	,837	2[b]
6. The shopping mall provides no added value for the growth phase, because info also can be found elsewhere [a]	0	1	0	4	0	3,6	,894	4
Maturity phase								
7. The shopping mall provides services that are useful for the daily operation of a local energy initiative	0	0	2	3	0	3,6	,548	4

Usefulness statements	Scale					Eemstroom		
Statement	1	2	3	4	5	(N=5)		
						μ	*σ*	*M*
8. The shopping mall provides useful services that support local balancing of energy demand and supply	0	1	2	2	0	3,2	,837	3[b]
In general								
9. Who fulfils the role of the shopping mall facilitator is of no importance for the local energy Initiatives [a]	0	1	1	3	0	3,4	,894	4
10. The shopping mall provides services that are useful for the individual participants of a local energy initiative	0	0	1	4	0	3,8	,447	4
11. The shopping mall provides insight in which services are available for local energy initiatives now and will be available in the future	0	1	1	3	0	3,4	,894	4

a. Results have been recoded from negative to positive

b. Multiple modes exist. The smallest value is shown

Table 18 shows the results of the open questions of the Eemstroom session.

Table 18: Results of open questions Eemstroom session

Statement	Results Eemstroom	(N=5)
12. Top 3 of shopping mall's added value	1) All services in one place	5
	2) The shopping mall reliefs local energy initiatives	3
	3) Settle bill at one place	2
Open questions	***Clustering of written quotations***	
13. Terms and conditions for acceptance to use the shopping mall	- Privacy and security of the information	2
	- Trustworthy partners	2
	- Ease of use	1

Statement	Results Eemstroom	(N=5)
	- A full assortment from providers	1
	- Good ICT support	1
	- Personalisation (own logo)	1
	- Advice and tips from other members	1
	- Organisation should have an overview of what is happening	1
14. Added value for prosumer community	- All relevant info and products at one place (one stop shopping)	4
	- A large supply of services	1
	- Relief of prosumer communities	1
15. Strong points of the shopping mall	- Counter function: everything can be found in one place	5
	- Central control on relevance of the offered services	1
	- Can be copied to other regions so it will be recognizable for families in other regions	1
16. Weak points of the shopping mall	- Better explanation and guidance through the process	3
	- Icons are not always clear	1
	- Use of English language and terminology	1
	- An average person does not know what he has to do to realise conservation	1
	- It is not possible to facilitate the nuances and details of the various regions	1
	- It could be complicated to offer one standard that works for all services	1
17. Essential missing elements in the shopping mall	- A good search engine (a la Google)	1
	- Introduction page	1
	- Benchmark/comparison of energy usage	1
	- Facilities to contact peers	1
	- When should I come back?	1
	- How is data storage handled: at shopping mall, at customer, at service provider?	1
18. Other remarks	- Social aspects. What is important for the neighbourhood - A number of elements are presented (too) simplistic, implementation asks for substantial effort - Why should people participate in an initiative? - Good initiative - Be aware that many people are not familiar with the used terminology	

Usefulness evaluation analysis

The five Eemstroom respondents score positive on the mall's usefulness aspects '(4) support for setting-up a local energy project' and '(10) providing useful services for individual prosumer community participants', while they are moderately positive on '(3) support for realising local sustainable energy supply' and '(7) providing useful services for the daily operation of a local initiative'. Furthermore, the score on the statement that the shopping mall '(6) provides added value for the growth phase' is also moderately positive. There is no agreement on the other six statements regarding the usefulness of the shopping mall.

Whether the shopping mall enhances the prosumer communities decision process in the various life cycle phases, cannot be answered unambiguously. The respondents are moderately positive about the support in the emerging growth phase, but for the start-up phase and the maturity phase they are not univocal.

Table 18 shows that at the top 3 'all services in one place' is scored as the highest added value, which is supported by the quotations on the open questions on '(14) Added value for prosumer communities' and '(15) Strong points of the shopping mall'. The Eemstroom respondents mainly refer to usability aspects in their response to the open questions 16 and 17 on weak and missing points of the shopping mall.

Privacy and security, as well as trustworthy partners were mentioned as important prerequisites for prosumer communities that must be fulfilled, prior to starting to use the shopping mall.

In the discussion during the session the shopping mall was appreciated as being a powerful concept. But at the same time it was commented that some implementation aspects were underexposed: 1) who is going to implement the shopping mall; 2) what is the underlying business model; 3) the complexity of the back office processes. According to some of the respondents, a number of aspects need to be worked out into more detail, like who owns the data (privacy, security), and how the independent role of the mall facilitator can be guaranteed. One respondent observed: "Energy and energy exchange are not sexy at all, next to the fact that many people think it is far too complicated." The social aspects were also mentioned as being important to convince people to participate (Quote: "The social context is important. When your neighbour says: you need to buy this app, that would help. Use the word of mouth!"). One of the respondents remarked that he had difficulty with the English terminology that is being used in the prototype.

7.6 GrEK community session

GrEK, the Groninger Energie Koepel, is a cooperative for prosumer communities in the province of Groningen. Their aim is 'to inspire, encourage, connect, support, and train local village associations and local energy cooperatives, who work on energy conservation projects and the production of sustainable energy'. Their slogan is: be in charge of sustainable and social energy.

The session

Via the GrEK organisation a number of representatives of prosumer communities were invited to participate in the evaluation session. The session was planned as part of one of the regular expert meetings, which are frequently scheduled for the participating initiatives. The expert meetings are intended for sharing knowledge and information, and for sharing thoughts and ideas on strategies for further development of initiatives. Seven people, representing four different prosumer communities, participated in the session, which took place at the school building where one of the participants works.

During and after the introductory presentation, a lively discussion was started by the participants on motivations of local energy initiatives and the scope of their activities. In their opinion the scope of the initiatives should be broader than (electricity) production alone; gas (biomass) and heat should also be incorporated. It was stated that Trias energetica[33] should be the basic principle, starting with energy savings. The participants amplified that the diversity of initiatives makes it hard to make a comparison. Let alone to make a comparison with other countries, while the national conditions are very diverse (e.g. legislation, subsidy schemes). Another point that was brought forward was the role of the authorities. It was mentioned that legislation is slow in following new developments and these constant arrears often hamper the progress of local initiatives. Furthermore, it was stated that the long term sustainability policy often is not consistent, which makes the authorities an unreliable partner.

The presented shopping mall made the participants curious for the implementation, although one of them remarked to find it hard to put himself into someone else's position, as he formulated: "My problem is that I am going to walk around in the shopping mall and doing impulse purchases, because I do not know what my problem is."

[33] The term Trias energetica was introduced by Duijvestein (1996). It provides a three-step approach to achieve a sustainable energy system: 1) prevent waste of energy, 2) use sustainable resources, and 3) use fossil fuels as efficient as possible.

During the task assignment one of the respondents remarked: “In my local initiative board I work with a doctor and with a manager of a nursing home (“paper boys”). They all want to do something with local sustainable energy (e.g. solar panels). They are not used to work with systems like this. It is too much information, far too complicated because it is not their daily business. Why not presenting just the information that I request, that I want, that covers the things I am working on? Those people pick up the phone and call the alderman, who they probably know from the pub, and ask him what they have to do and how to do it. How do you convince them to use a system like this?” Another remark that was made: “Local energy initiatives represent highly motivated and interested people, but they are not necessarily well-grounded in this subject.”

Usefulness evaluation results

Table 19 shows the results of the usefulness statements of the GrEK session questionnaire that was filled in by the seven respondents.

Table 19: Results of usefulness statements GrEK session

Usefulness statements	**Scale**					**GrEK**		
Statement	**1**	**2**	**3**	**4**	**5**	**(N=7)**		
						μ	***σ***	***M***
Start-up phase								
1. The shopping mall provides relevant information and examples for starting-up a local energy initiative	0	0	0	5	2	4,3	,488	4
2. The shopping mall provides no added value for the start-up phase, while info also can be found elsewhere [a]	0	0	2	5	0	3,7	,488	4
Emerging growth phase								
3. The shopping mall provides support for the selection process of local energy supply	0	0	1	4	2	4,1	,690	4
4. The shopping mall provides support for setting-up a local energy project	0	0	1	5	1	4,0	,577	4

Usefulness statements	Scale					GrEK (N=7)		
Statement	**1**	**2**	**3**	**4**	**5**	***μ***	***σ***	***M***
5. The shopping mall provides services for member and customer recruitment [c]	0	0	2	2	1	3,8	,837	3[b]
6. The shopping mall provides no added value for the growth phase, because info also can be found elsewhere [a]	0	0	2	5	0	3,7	,488	4
Maturity phase								
7. The shopping mall provides services that are useful for the daily operation of a local energy initiative	0	0	3	3	1	3,7	,756	3[b]
8. The shopping mall provides useful services that support local balancing of energy demand and supply	0	1	1	5	0	3,6	,787	4
In general								
9. Who fulfils the role of the shopping mall facilitator is of no importance for the local energy initiatives [a]	0	0	1	2	4	4,4	,787	5
10. The shopping mall provides services that are useful for the individual participants of a local energy initiative	0	0	0	6	1	4,1	,378	4
11. The shopping mall provides insight in which services are available for local energy initiatives now and will be available in the future	0	0	3	2	2	3,9	,900	3

a. Results have been recoded from negative to positive

b. Multiple modes exist. The smallest value is shown *c. Two missing scores*

Table 20 shows the results of the open questions. For each question, the similar answers have been clustered. The last column in the table shows how many respondents gave a similar answer.

Table 20: Results of open questions GrEK session

Statement	**Results GrEK**	**(N=7)**
12. Top 3 of shopping mall's added value	1) All services in one place	5
	2) Continuous renewal of the service offering (flexibility)	3
	3) Services are selected and offered by a trustworthy party	4
Open questions	***Clustering of written quotations***	
13. Terms and conditions for acceptance to use the shopping mall	- Up to date and reliable information	5
	- Transparency and independency: who is the one behind the shopping mall?	2
	- What are the costs of shopping?	1
	- No direct after sales by service providers	1
	- It should be easy to use	1
	- It should have added value	1
14. Added value for prosumer community	- Broad spectrum of offerings in one place and meticulously preselected	4
	- Directive through checklists and templates	2
	- No commercial interests	1
	- Usability and accessibility	1
15. Strong points of the shopping mall	- Everything in one place (one stop shopping)	7
	- Up to date	1
	- Not commercial	1
	- The coupling of different services (personalisation, e.g. service that links PV panels to charging an electric vehicle)	1
16. Weak points of the shopping mall	- The user interface and navigation	3
	- Far too many services (stress of choice)	1
	- The concept is not clear to me and confusing. It is "just" a start page but then for energy initiatives, and that is broad, too broad	1
	- Experiences of projects should also be presented	1
	- Fully reasoned from the perspective of supply, not demand	1

Statement	Results GrEK	(N=7)
	- Publicity – many interested people are lost in the woods	1
17. Essential missing elements in the shopping mall	- Time is too short to evaluate this properly and the range is too wide - I would arrange the navigation based on projects and by using checklist, much of the information can be left out - Only choice options on the highest level? - Energy storage	2 1 1 1
18. Other remarks	- I doubt what is the added value of this, while there is also the goal to get a PhD degree - Time is too short to evaluate this properly - Where is the border line between advice and commercial activity? - Don't make it too complicated. Much of the work is done by volunteers - I am curious for the criteria being used to be allowed access to the site - Good idea/initiative	

Usefulness evaluation analysis

The GrEK session respondents were overall positive on almost all the items concerning the shopping mall's usefulness, as one of the respondents remarked: "Such a system fulfils a need: here you find what you need when you want to start up an initiative." Specifically the statements '(1) useful for starting-up an initiative', '(3) support for realising local sustainable energy supply', '(4) support for setting-up a local energy project', '(9) it is relevant for prosumer communities who fulfils the role of mall facilitator', and '(10) providing useful services for individual prosumer community participants' were scored high ($\mu \geq 4{,}0$). Other positively scored statements were on '(2) the added value for starting-up an initiative', '(6) the added value for the growth phase', '(7) the useful service offering for the daily operation', and on '(11) providing insight in current and future service offerings'. Statement 8, related to 'the provision of useful services for local demand and supply balancing' was scored moderately positive, although the scores were dispersed. The statement regarding '(5) offering useful services for member and customer recruitment' was also scored positive, although two respondents did not score this item. One of them remarked that he did not see this functionality during the task assignment. The researcher suggested the respondents to still look it up in the prototype, or otherwise leave the score open.

We can conclude that the usefulness of the shopping mall for enhancing prosumer communities in their various life cycle phases overall was scored positive by the GrEK respondents.

The results of the open questions indicate that the shopping mall's 'broad collection of services in one place' is considered to be the strongest point with the highest added value. The weak and missing points that were mentioned in majority are related to the usability aspects of the prototype. Two of the respondents indicated that the session time was too short to be able to fully understand the shopping mall and to evaluate it properly.

The GrEK respondents mentioned as important acceptancy perquisites that the shopping mall's information should be reliable and up-to-date. Furthermore, it was indicated that the role of the shopping mall facilitator should be transparent and independent.

7.7 The expert sessions

Next to the three prosumer community group evaluation sessions, eight expert evaluation sessions were conducted.

The sessions

Various professionals from the energy sector were approached with the request to participate in an individual expert evaluation session. In the end eight experts participated. Most of the sessions took place at the expert's work or home premises. The structure and content of the sessions were similar to the prosumer community sessions: first the introductory presentation and a short prototype demonstration, followed by the prototype task assignment, and finally filling in the questionnaire. The only difference in the session were the last two questions of the questionnaire on demographic data. These questions were related to the expert's professional assignment (organisation, function) and his relation to local energy initiatives (see also Appendix 6).

Usefulness evaluation results

Table 21 shows the results of the usefulness statements of the expert sessions questionnaires that were filled in by the eight respondents.

Table 21: Results of usefulness statements expert sessions

Usefulness statements	Scale					Experts		
Statement	1	2	3	4	5	(N=8)		
						μ	*σ*	*M*
Start-up phase								
1. The shopping mall provides relevant information and examples for starting-up a local energy initiative	0	1	2	3	2	3,8	1,035	4
2. The shopping mall provides no added value for the start-up phase, while info also can be found elsewhere [a]	0	1	2	5	0	3,5	,756	4
Emerging growth phase								
3. The shopping mall provides support for the selection process of local energy supply	0	1	0	7	0	3,8	,707	4
4. The shopping mall provides support for setting-up a local energy project	0	0	1	7	0	3,9	,354	4
5. The shopping mall provides services for member and customer recruitment [c]	0	1	1	4	1	3,7	,951	4
6. The shopping mall provides no added value for the growth phase, because info also can be found elsewhere [a]	0	1	2	4	1	3,6	,916	4
Maturity phase								
7. The shopping mall provides services that are useful for the daily operation of a local energy initiative	0	1	1	5	1	3,8	,886	4

Usefulness statements	Scale					Experts (N=8)		
Statement	**1**	**2**	**3**	**4**	**5**	***μ***	***σ***	***M***
8. The shopping mall provides useful services that support local balancing of energy demand and supply	1	0	0	6	1	3,8	1,165	4
In general								
9. Who fulfils the role of the shopping mall facilitator is of no importance for the local energy initiatives [a]	0	0	0	4	4	4,5	,535	4[b]
10. The shopping mall provides services that are useful for the individual participants of a local energy initiative	0	1	0	5	2	4,0	,926	4
11. The shopping mall provides insight in which services are available for local energy initiatives now and will be available in the future	0	0	3	4	1	3,8	,707	4

a. Results have been recoded from negative to positive
b. Multiple modes exist. The smallest value is shown
c. One score missing

Table 22 shows the results of the open questions. For each question, the similar answers have been clustered. The last column in the table shows how many respondents gave a similar answer.

Table 22: Results of open questions expert sessions

Statement	Results Experts	(N=8)
12. Top 3 of shopping mall's added value	1) The shopping mall reliefs local energy initiatives	3
	2) All services in one place	3
	3) Interoperability of services	6
Open questions	***Clustering of written quotations***	
13. Terms and conditions for acceptance to use the shopping mall	- Trustful and transparent system and facilitator	4
	- Who exploits the shopping mall (independency)	3
	- It should support the business model of the cooperative	2
	- Good information provision and support	2
	- Useful and affordable	2
	- Freedom of choice	1
	- Policy with respect to privacy and security should be clear	1
	- Strengthening of the collective	1
	- No upfront conditions; when high quality is offered, they will start using it, and then conditions will follow	1
14. Added value for prosumer community	- Accessibility and overview of all aspects that play a role	2
	- Bundling of relevant info and services in one place	2
	- Relief (make or buy)	2
	- Makes access to the community easily and accessible	2
	- Facilitates (new) services for cooperatives	2
	- Guarantee of interoperability	1
	- Strengthening of the collective	1
	- Communication and sharing experiences	1
15. Strong points of the shopping mall	- One stop shop (advice and market place)	5
	- Clear overview of all the aspects that play a role	1
	- Info is easy to find, and it is fun	1
	- Guarantee of interoperability	1
	- Relief	1
	- Bring together demand and supply	1
	- "Platform" for community	1

Statement	Results Experts	(N=8)
16. Weak points of the shopping mall	- The concept's feasibility	4
	- Usability and navigation	2
	- The threshold (i.e. registration) is still rather high for parties in start-up phase	1
	- Facilitation of the role of the community => connect people and personalised design of relevant information	1
	- How to avoid potential lock-in	1
	- When sponsors are involved, how to guarantee an independent platform	1
	- Role of facilitator: is he trustful; what's in it for him?	1
	- Use of Dutch and English is mixed => causes semantic confusion	1
	- Broad service spectrum asks for high knowledge level of users	1
	- Complexity of some services is presented too simplistic	1
17. Essential missing elements in the shopping mall	- No room for non e-services	1
	- Personification/branding of community	1
	- The interplay and competition between service providers	1
	- Information concerning the facilitator	1
	- Test whether the selected service really works or not (guarantee of interoperability)	1
	- Advice functions to initiatives are underexposed	1
	- Better guidance	1
	- Community focussed services	1
18. Other remarks	- Nice to see how this concept is worked out - Probably you could learn from shopping formulas and franchise models? - How to incorporate the interrelationship between the various elements in the shopping mall concept (e.g. advice, inspiration)? - To my opinion such a concept can only be realised by a financially strong party - Local initiatives generally mistrust the average large party - Business wise the sales cycle for SME's should be short; the concept covers that - Social elements could be stronger worked out	

Usefulness evaluation analysis

Although the eight expert sessions were on an individual basis, and the experts had a diverse background, they were almost unanimously positive on two usefulness aspects: they agreed that the shopping mall provides support for '(4) setting-up a local energy project' and that '(9) it is relevant for prosumer communities who fulfils the role of the shopping mall facilitator'. The same goes for the statements that the shopping mall provides support for '(3) choosing how to realise local sustainable energy supply' and '(10) useful services for individual members', where one respondent disagreed[34] while the rest was positive. Furthermore, they were positive on the usefulness of the mall with respect to '(8) providing services for local demand and supply balancing', although one respondent[34] strongly disagreed with this statement. The experts were also positive on the statement that the mall '(11) provides insight in current and future services'. They were moderately positive on the usefulness statements of '(2) providing useful services for starting-up an local energy initiative', '(5) providing useful services for member and customer recruitment', '(6) the added value for the emerging growth phase', and '(7) providing services for the daily operation of an initiative', although the spread of the scores on these four statements was rather large. There was no agreement on statement '(1) provision of relevant services for starting up a local energy initiative'.

Overall, we can conclude that the experts were positive to slightly positive on the usefulness of the shopping mall in providing support for the emerging growth phase. They were slightly positive on the support for both the start-up phase and the maturity phase, although the scores were rather spread.
The results of the open questions of the questionnaire show that 'one stop shopping' is seen as the strongest point and one of the main added values of the mall. The highest top 3 score was on the functionality ' the shopping mall provides relief for local energy initiatives'.
Respondents brought forward that the feasibility of the shopping mall needs to be worked out in more detail. Some of the experts placed footnotes whether the business model would be viable, although one expert noted: "The business case of the shopping mall is evident. The question remains: when to invest? Now, or within a few years?"

The prerequisite that was noted most often, relates to the role of the mall facilitator. In this context trust and transparency were mentioned a couple of

[34] The scores of one of the expert respondents were overall significantly more negative than the scores of the other experts. When this score would be left out, the overall score on usefulness would be more positive.

times ("Who owns the data that is offered by the communities, and what is done with it?"). Another condition mentioned was that the shopping mall should connect to the business model of the initiatives.

7.8 Collective results of the usefulness evaluation

In this section we analyse the results of the usefulness evaluation of all the sessions together. Table 23 presents the results of the statements of all the sessions with respect to the usefulness aspects of the shopping mall. It shows the collective scores for each statement, as well as the mean (μ), the standard deviation (σ) and the Mode (M).

Table 23: Results of usefulness statements of all sessions

Usefulness statements	**Scale**					**All**		
Statement	**1**	**2**	**3**	**4**	**5**	**(N=25)**		
						μ	***σ***	***M***
Start-up phase								
1. The shopping mall provides relevant information and examples for starting-up a local energy initiative	0	2	5	13	5	3,8	,850	4
2. The shopping mall provides no added value for the start-up phase, while info also can be found elsewhere [a]	0	3	6	16	0	3,5	,714	4
Emerging growth phase								
3. The shopping mall provides support for the selection process of local energy supply	0	1	5	17	2	3,8	,645	4
4. The shopping mall provides support for setting-up a local energy project	0	0	3	21	1	3,9	,400	4
5. The shopping mall provides services for member and customer recruitment [b]	0	4	6	9	3	3,5	,964	4

Usefulness statements	Scale					All		
Statement	1	2	3	4	5	(N=25)		
						μ	*σ*	*M*
6. The shopping mall provides no added value for the growth phase, because info also can be found elsewhere [a]	0	2	6	16	1	3,6	,700	4
Maturity phase								
7. The shopping mall provides services that are useful for the daily operation of a local energy initiative	0	2	7	13	3	3,7	,802	4
8. The shopping mall provides useful services that support local balancing of energy demand and supply	1	2	5	15	2	3,6	,913	4
In general								
9. Who fulfils the role of the shopping mall facilitator is of no importance for the local energy initiatives [a]	0	1	3	12	9	4,2	,800	4
10. The shopping mall provides services that are useful for the individual participants of a local energy initiative	0	1	2	18	4	4,0	,620	4
11. The shopping mall provides insight in which services are available for local energy initiatives now and will be available in the future	0	3	8	11	3	3,6	,838	4

a. Results have been recoded from negative to positive

b. Three missing values (N=22)

Usefulness evaluation

When we look at the results of all the sessions, the following observations can be made:

- The respondents are positive on the usefulness for *the start-up phase*, because they agree that '(1) the shopping mall provides relevant information and examples for starting-up a local energy initiative', and they moderately agree with the statement that '(2) the shopping mall provides added value for the start-up phase'.
- The usefulness of the shopping mall for *the emerging growth phase* is confirmed by the respondents, because they are positive on the support for both '(3) realising local energy supply' and '(4) setting-up a local energy project'. This is endorsed by the fact that they agree with the statement that the shopping mall '(6) provides added value for the emerging growth phase'. The scores on the statement that the shopping mall '(5) provides services for member and customer recruitment' are more dispersed, so there is no univocal agreement on this statement, although the majority of the scores is positive. Three respondents did not score this statement.
- The scores on the shopping mall's usefulness for *the maturity phase* are positive on '(7) support for the daily operation of a local energy initiative', but there is no univocal agreement on the statement '(8) the shopping mall provides useful services for local energy balancing', although the majority of the scores is positive.
- Respondents agree that '(9) it is of interest for prosumer communities who is fulfilling the role of the mall facilitator'. There is also high consensus on the usefulness of the shopping mall for '(10) the individual participants of an initiative'. The statement that '(11) the shopping mall provides insight in both currently and future available services for local energy initiatives' receives dispersed scores, so there is no explicit consensus on this statement, although in majority scores are positive.

Is it correct to join the results of the various sessions and make statements on the analyses? To verify this, we performed an *Independent-Samples T Test*, where we compared, for every combination of two sessions, the outcomes of the statements that were scored on the Likert scale. Our null hypotheses H_0 was that there is no significant difference in the outcomes of the various sessions (α=0,05). On all comparisons of usefulness statements, except for one[35], the scores were higher than 0,05, and therefore we can accept our null

[35] There was one exception in the comparison between the GrEK session and the experts session for statement 9 on the role of the mall facilitator (Sig.(2-tailed) = 0,018).

hypothesis. The results of the Independent-Samples T Test are listed in a separate report (Timmerman, 2015).

Table 24 below shows the collective results of the open questions, where similar answers have been clustered. Only the answers that were written down more than twice are selected.

Table 24: Collective results of open questions, with the most cited quotations

Statement	**Results all sessions**	**(N=25)**
12. Top 3 of shopping mall's added value	1) All services in one place 2) The shopping mall reliefs local energy initiatives 3) The service offering is continuously updated	18 8 12
Open questions	***Clustering of written quotations***	
13. Terms and conditions for acceptance to use the shopping mall	- Complete, up-to-date and reliable information and services - Trustful and transparent system and facilitator (independency) - Accessible, attractive, and easy navigation - Trustworthy partners - Privacy and security of the information - It should support the business model of the cooperative - Useful and affordable - Personalisation	11 9 4 2 2 2 2 2
14. Added value for prosumer community	- All services in one place(one stop shopping) - Directive through checklists and templates - Facilitates (new) services for cooperatives - Relief (make or buy) - Guarantee of interoperability	16 2 2 2 2
15. Strong points of the shopping mall	- Large collection of information and services in one place(one stop shopping)	22
16. Weak points of the shopping mall	- The shopping mall prototype could give more guidance during the navigation - The concept's feasibility - Far too many services (stress of choice) - Use of English language and terminology makes it complicated	12 4 2 2

Statement	Results all sessions	(N=25)
17. Essential missing elements in the shopping mall	- Clear navigation structure and navigation guidance - Time is too short to evaluate this properly and the range is too wide - Benchmarking services - Community focused services	7 2 2 2
18. Other remarks	<u>Accessibility</u> - The system should be open, not closed - I am curious for the criteria being used to be allowed access to the site <u>Usability</u> - I need to scroll a lot to get a good overview - Be aware that many people are not familiar with the used terminology - Don't make it too complicated. Much of the work is done by volunteers <u>Social aspects</u> - Social aspects. What is important for the neighbourhood - Social elements could be stronger worked out <u>Business case</u> - I am very curious for the business case - Business wise the sales cycle for SME's should be short; the concept covers that - Where is the border line between advice and commercial activity? - Probably you could learn from shopping formulas and franchise models? - Sales are underexposed - To my opinion such a concept can only be realised by a financially strong party - Local initiatives generally mistrust the average large party <u>Technical implementation</u> - A number of elements are presented (too) simplistic, implementation asks for substantial effort <u>Diverse</u> - Why should people participate in an initiative? - I doubt what is the added value of this, while there is also the goal to get a PhD degree	

Statement	Results all sessions	(N=25)
	- Time is too short to evaluate this properly - How to incorporate the interrelationship between the various elements in the shopping mall (e.g. advice, inspiration)?	
	<u>Compliments</u> - Good initiative - Good idea/initiative - Nice to see how this concept is worked out	

The collective results of the open questions in Table 24 show a clear picture of what the respondents consider to be the most added value and the strongest point of the shopping mall, namely 'the large collection of information and services in one place'. This is confirmed by the scores in the top 3 of the shopping mall's added value: the highest score is on 'All services in one place'.

The weak points and missing elements of the shopping mall primarily relate to the usability aspects of the prototype implementation. The usability issues are further described in Section 7.9.

Other remarks that were noted down at the last open question of the questionnaire are related to accessibility, usability, the social aspects, the business case and the technical implementation of the shopping mall.

Acceptability of the shopping mall

In open question 13 respondents were asked what they thought to be the main prerequisites prosumer communities would pose before starting to use the shopping mall. Trust and reliability are the phrases that came forward most often. Trust and reliability are linked to both the content of the shopping mall (i.e. complete and up-to-date information and services) and the facilitation of the mall (i.e. service system, facilitator and partners). Respondents indicated that the content should be attractive, but affordable, where affordability relates to the business model of the prosumer communities. Usability aspects were also mentioned as important prerequisites, like easy navigation and personalisation, next to privacy and information security.

7.9 Usability and session facilitation evaluation results

The usability aspects of the prototype were also addressed in the evaluation. After all, the collected usability feedback on the prototype can be used for further improvements for another implementation of the shopping mall.

Table 25 shows the scores of all sessions for each of the statements on the usability aspects of the prototype, as well as the scores on the session facilitation. For each statement the mean (μ), the standard deviation (σ) and the Mode (M) is given.

Table 25: Results of the usability and session facilitation statements of all sessions

Usability and session facilitation	**Scale**					**All**		
Statement	**1**	**2**	**3**	**4**	**5**	**(N=25)**		
						μ	***σ***	***M***
Usability								
19. The structure of the shopping mall is clear and logical	0	4	10	10	1	3,3	,802	3[a]
20. The shopping mall is visual attractive	0	11	7	6	1	2,9	,927	2
21. The interface of the shopping mall is clear and easy to use	1	4	8	11	1	3,3	,936	4
22. It is easy to navigate through the shopping mall	0	5	3	16	1	3,5	,872	4
23. The nomenclature and terminology is clear	1	4	11	8	1	3,2	,898	3
24. The shopping mall provides sufficient feedback during navigation	0	5	11	8	1	3,2	,816	3
Session facilitation								
25. The tasks were clearly formulated and easy to fulfil	0	1	2	18	4	4,0	,628	4
26. In advance it was clear to me what was expected from me	0	2	5	12	6	3,9	,881	4
27. During the session I experienced sufficient room for individual input	0	1	2	14	8	4,2	,746	4

a. Multiple modes exist. The smallest value is shown

Usability evaluation

With respect to usability, the statements '(19) clear and logical structure', '(21) clear and easy to use interface', and '(22) ease of navigation' have a moderately positive score, although the scores are rather dispersed. Statement '(20) visual attractiveness' has a moderately negative score. There is no agreement among the respondents on the other two usability statements. Although there are no explicit positive or negative scores on the usability aspects, it is reasonable to conclude that the usability of the shopping mall prototype needs some improvements. This conclusion is emphasized by the outcomes of the questionnaire's open questions, as is described in the previous sections. The issues that were brought forward most often at the questions on weak and missing points of the shopping mall (see Table 24), were all related to the usability aspects of the shopping mall prototype ('the shopping mall could give more guidance during navigation', 'lack of clear navigation structure and navigation guidance'). One of the respondents commented that the shopping mall should also be accessible and easy to use for non-expert users, as he noted: "Local energy initiatives represent highly motivated and interested people, but they are not necessarily well-grounded in this subject." The strength of the prototype implementation for demonstration and evaluation purposes is reflected by the comment of one of the respondents: "It is very nice to see a worked out concept. Showing it is better than talking about it. It visualises and demonstrates how complex it can be to set up a local energy community."

For the usability evaluation statements, we also performed an *Independent-Samples T Test*, where we compared, for every combination of two sessions, the outcomes of the usability statements. Only two session comparisons (i.e. AmersVolt-GrEK resp. GrEK-experts) showed significant differences on a number of usability statements (statements 19, 21, 22 and 23). All other session comparisons showed no significant differences on the usability scores. The results of the Independent-Samples T Test are listed in a separate report (Timmerman, 2015).

Session facilitation evaluation

Considering the scores on the session facilitation (statements 25 up to and including 27), overall we conclude that the respondents were satisfied with the way how the sessions were facilitated. The statement on 'upfront expectation of the session' had some more neutral and negative scores, but nevertheless the overall score was mainly positive.

7.10 Summary

The evaluation results indicate that the shopping mall is useful for enhancing prosumer communities in making decisions in the first two phases along their growth path. The usefulness scores for the decision enhancement in the maturity phase are not univocal, although positive in majority. Furthermore, the usefulness for individual prosumer community participants is confirmed by the respondents. The main strong points of the shopping mall that were brought forward as being of added value for prosumer communities are 'the large collection of services in one place', which are 'continuously updated', while 'the shopping mall relieves prosumer communities'. The role of the shopping mall facilitator is seen as a major prerequisite for the prosumer communities before they want to start using the mall. More specifically, the key point is which actor will fill in the mall facilitator role: this actor should be independent, trustful, and transparent.

The evaluation results further show that the usability of the shopping mall is considered to be important. The way it was implemented in the prototype, concerning both navigation structure and user interface, could be improved. Also, some issues related to the shopping mall's feasibility were expressed. These subjects will be further discussed in the next chapter.

8 Epilogue

In this final chapter we reflect on the main findings of our research and its generalisability, and the research rigour and relevance. Furthermore, we address the contributions made by our research. We finish this chapter with proposing directions for further research.

8.1 Research findings

For our study we chose design science as our research philosophy. Hevner & Chatterjee (2010) formulated that design science research focuses on "understanding real-life phenomena, identifying practical problems and related requirements, and designing explicitly applicable solutions introducing appropriate artefacts that can serve human purposes."

We started this research at the time some prosumer communities took off. We observed that many initiatives are struggling with the complexities of the energy sector, which are related to technology, financial risks, public acceptance, and commercial and political interests (Walker et al., 2007). In our case studies we identified a number of problems that prosumer communities ran into (Chapter 3). These problems appear to be related to the pace of development of the initiatives, which directly links to the complexity of the energy business and the lack of availability of the right expertise and resources within the community. Furthermore, prosumer communities experienced that complex legislation and the complexity of energy technology for realising energy projects were also barriers for smooth progress towards reaching their goals: realising a locally based sustainable energy provision for their members and with their members.

Based on the above observations, we formulated the main research objective: **to develop a decision enhancement environment for prosumer communities and thus supporting them along their growth path.**

In Chapter 1 we formulated the main research question and three research sub questions in order to achieve this objective. The following sections elaborate on each of these questions.

Research sub question SQ1: How does the growth path of prosumer communities look like?

The objective of answering this question was to gain insight in the development process of prosumer communities and identify which decisions were involved in the various life cycle phases of their growth path.

Chapter 2 provides the basis for answering this sub question by reviewing literature from three different perspectives: people, process and technology. The three perspectives, related to decision enhancement (Keen & Sol, 2008), each form a cornerstone for the establishment of a prosumer community: who are involved in which role in the development process, and what are their motivations (the people), how are prosumer communities organised and in which context do they have to operate (the process), and which relevant technological developments can be applied to support both people and process (the technology).

Various sources designate the development of prosumer communities as an innovation process (Allen et al., 2008), which is part of the energy transition process (Verbong & Geels, 2010). As such, the development of prosumer communities can be characterised as dynamic, non-linear, and consisting of various iterative phases, with many complexities involved that ask for choices and strategic decisions (Walker et al., 2007). From the literature review we concluded that bits and pieces for decision enhancement are available, but that an integrated concept encompassing the full range of decision making along the prosumer communities' growth path, is still missing. Following the inductive-hypothetic research strategy (Sol, 1982), we conducted an exploratory study, elaborated in Chapter 3, which provided us with deeper insight in the problems and complexities encountered.

The empirical data that was gathered within the exploratory study was further analysed in Chapter 4 using the analytical-evaluative framework of Forrest & Wiek (2014). Based on the organisational life cycle model (Jawahar & McLaughlin, 2001; Lattemann & Stieglitz, 2005), we identified four life cycle phases that can be projected onto the growth path of prosumer communities: *the start-up phase*, the *emerging growth phase*, *the maturity phase* and *the decline or revival phase*. For the first two life cycle phases, we identified various activities that are characteristic for that phase:

- The start-up phase is characterised by the activities of idea generation, formation of a legal entity and creation of a business plan.
- The emerging growth phase is characterised by activities such as member recruitment, working group formation, service portfolio organisation and operationalisation, and the organisation of local

energy supply. In this phase first steps are taken to realise collective local sustainable energy projects, while pilot projects are initiated to experiment with smart grid technologies and smart energy services.

We concluded, based on the case study findings, that many prosumer communities are still in the emerging growth phase, although first steps are being made to enter into the maturity phase. We developed a solution, the shopping mall, that helps prosumer communities to further grow and guides them towards the maturity phase. The decline or revival phase is not further addressed in this research.

From the analysis of the exploratory study, we identified and described the life cycle phases of the prosumer communities' growth path, as well as the associated activities for the first two life cycle phases, and with that we answered research sub question SQ1.

Research sub question SQ2: What are the requirements of prosumer communities for decision enhancement along their growth path?

The objective of this research question was to identify the requirements that need to be satisfied when designing a solution for prosumer community decision enhancement. With the stepwise analysis (Forrest & Wiek, 2014) of the exploratory study results in Chapter 4, we identified which decisions were involved in solving problems in the various activities along the prosumer community's growth path, and what was needed to make these decisions. Based on the identified needs and demands we formulated the following generic requirements for enhancing prosumer communities' decisions, thus answering SQ2:

R1. ***Guidance:*** *the solution must provide guidance to prosumer communities in finding the right information and expertise.*

R2. ***Information access in one place:*** *the information resources must be available, or at least accessible in one place.*

R3. ***Just in time information availability****: the solution must present the information in sync with the needs and demands of the user.*

R4. ***Location dependent information:*** *information provided should be, when appropriate, locally or regionally demarcated.*

R5. ***Ready-made versus custom-made:*** *the solution must be adaptable to the specific needs of the local prosumer community.*

R6. ***Tool and service selection:*** *the solution must provide a rich set of services and tools, which should be well-structured and organised in order to guide users in deciding on selection.*

R7. ***Services for end-users:*** *specific tools and services should be made available for individual prosumer community participants.*

R8. **Trustworthy solution provider*:*** *the party that provides the solution should be trustworthy, where users have the choice to decide on automatic control. Tools and services should be easy to use.*

R9. ***Standardisation:*** *standards should be used in order to guarantee interoperability and scalability of the solution.*

Research sub question SQ3: How does a solution look like that meets the requirements?

By answering this research question we wanted to formulate a theory for the decision enhancement of prosumer communities and create an artefact that provides an effective solution for solving prosumer communities' real-world problems. To articulate this contribution 'the way of' framework (Seligman et al, 1989; Sol, 1988) was used, introducing a new way of thinking, working, controlling and modelling with respect to decision enhancement for prosumer communities. The way of thinking incorporates the concepts and theoretical foundations underlying the solution. By following an abductive line of reasoning, we identified that prosumer communities, in their search process for the right information and expertise, typically show shopping behaviour. From this observation we introduced the shopping mall concept as an artefact that is based on the studio concept of Keen & Sol (2008). The shopping mall fuses the three main elements in decision making: *people, process* and *technology.* The shopping mall serves as a platform where prosumer communities and their members are facilitated in making decisions; they are stepwise guided in finding information, tools and expertise that they need, depending on the life cycle phase they are in. Service providers are facilitated in developing and deploying services that can be selected by the prosumer communities. The mall facilitator plays an important role as operator and manager of the shopping mall platform. Furthermore, the shopping mall satisfies eight of the nine requirements that were formulated in Chapter 4. The way of working, controlling, and modelling as described in Chapter 5 provide the blueprint for the artefact instantiation in the form of a prototype (Chapter 6).

Main research question RQ: How can prosumer communities be facilitated in enhancing their decisions along their growth path?

The objective of our research was to contribute to the growth and development of prosumer communities by providing a solution that would enhance their decisions as they encounter barriers and complexities along the road ahead. The shopping mall concept was evaluated in various sessions with prosumer community representatives and energy experts, showing that the shopping mall was perceived as useful and usable. These results indicate that the shopping mall facilitates prosumer communities in enhancing their decisions along their growth path.

Generalisability of the results

According to Wieringa (2014) 'design sciences do not aim at universal but at existential generalisations, and they do not make unrealistic idealisations in order to acquire knowledge, but aim to make only realistic assumptions about their object of study.'

The issues that were addressed in our exploratory study cover problems and complexities that are faced by many prosumer communities in the Netherlands. This is confirmed by the observations from our literature review (Chapter 2) and from the evaluation sessions with representatives of prosumer communities and energy experts (Chapter 7). This gives a strong indication that the artefact designed and instantiated is applicable for Dutch prosumer communities in general.

In our research we focussed on prosumer communities in the Netherlands. But the emergence of prosumer communities is not typically restricted to the Netherlands. Internationally we face similar principles of prosumer communities: trying to create a local sustainable region, to stimulate saving energy and money, and seeking to reinforce the local economy and local social cohesion (e.g. Bomberg & McEwen, 2012; Palm & Tengvard, 2011; Stokman, 2011; Watson et al., 2006). Although per country certain conditions for prosumer communities differ, for instance due to specific national legislation or different environmental circumstances, we argue that the shopping mall concept is that generic and flexible that such differences can be adapted. Thus, the shopping mall may provide a solution which can be instantiated for prosumer community decision enhancement in international contexts. Per country, the content of the shopping mall might be different due to for instance differences in legislation and financial regulations, and because different (local) service providers may be in play. International application of the shopping mall introduces an extra requirement of language independency.

8.2 Research rigour and relevance

This study has been conducted within the tradition of design science research. Design science research results are justified based on pragmatic validity: does the solution really lead to the intended results? The primary focus is not on 'truth' but on 'does it work and how'. Scientific rigour and practical relevance come together in design science research. Within our study an innovative artefact was created and implemented (Chapter 5 and 6) that solves real-world problems (Chapter 1, 3 and 4) and acquires knowledge and understanding of the related application domain and the solution to these problems (Chapter 4 and 5) (Hevner & Chatterjee, 2010).The artefact was field tested through evaluations in the application domain.

The inductive-hypothetic research strategy of Sol (1982) provided us with a clear roadmap for *how* to conduct our study, consisting of four consecutive phases: via exploration, understanding and design toward evaluation. The 'ways of' framework was used to transform the identified design issues into an artefact that explicitly solves the identified problems and serves human purposes (Hevner & Chatterjee, 2010; Peffers et al., 2007). The prosumer community shopping mall was used to demonstrate its usage and to evaluate its usefulness and usability (Keen & Sol, 2008). It was evaluated with representatives of prosumer communities and experts from the energy domain (Chapter 7). Several research instruments have been used throughout the study, including 1) literature review, 2) case studies, 3) group sessions with a Group Support System, 3) stakeholder and expert interviews, 4) analytical-evaluative framework for case study analysis, 5) 'the way of' framework for artefact design, and 6) questionnaires for the evaluation sessions.

Relevance of the research

When we started our research, the emergence of prosumer communities was relatively new as part of the transition process towards a sustainable energy system. We observed that prosumer communities were facing problems and complexities that hamper their development process. The design of the shopping mall provides a solution by offering a decision enhancement environment that facilitates prosumer communities in making decisions to solve these problems. The evaluation results underline the relevance of our research as the shopping mall is perceived as a useful and usable solution for decision enhancement. This is even more relevant because the number of Dutch prosumer communities grew substantially in the last three years: 75% of the energy cooperatives was established after January 2013 (Schwencke, 2016).

8.3 Research contributions

Gregor & Hevner (2013) remark that knowledge contributions of design science research vary: it could be partial theory, incomplete theory or an empirical generalisation in the form of a new design artefact. The type of theory for knowledge contribution from design science research is considered as prescriptive knowledge: it gives prescriptions for design and action. Additionally, Hevner et al. (2004) amplify the importance of making a clear contribution to the real-world application environment from which the research problem is drawn. According to Hevner & Chatterjee (2010) design science research contributions to the knowledge base might include any additions or extensions to original theories and methods that are being used during the research, new artefacts (design products and processes), and experiences gained from performing the design cycle and field testing.

In this research we used the theory and methods from decision enhancement (Sol, 1982) and applied the studio concept (Keen & Sol, 2008) in a new application domain, namely prosumer communities in the energy sector, which was not done before. The design artefact introduces a new concept, a decision enhancement environment offering services for prosumer communities. Furthermore, the concept is instantiated as a cloud-based online portal or app store, which is a new application form of the studio concept. The shopping mall also incorporates a framework for service providers to offer (new) services. Last but not least, the shopping mall represents a social contribution, as it adds value to the real-world application environment of prosumer communities. It is a generic but flexible solution, available for multiple prosumer communities, which can be attuned to the specific needs of the separate prosumer communities.

8.4 Directions for further research

The results of our study give multiple indications for further research related to local community decision enhancement, both within the energy domain as well as in other application domains. Possibilities for further research include:

1) **Adaptation of smart grid standards**
   The interoperability of the shopping mall services and the scalability of the shopping mall as a platform for prosumer community services demand an ICT architecture that provides standard interfaces for data and information exchange at all levels in the energy system - from the level of the grid operator down to the level of end users´ devices and appliances. The standard building blocks that are offered by the

shopping mall back office to the service providers should comply with these standard interfaces. The adaptation of smart grid standards[36] is an additional topic of research.

2) **Investigation of the role of the shopping mall facilitator**
Our research indicates that the role of the shopping mall facilitator is crucial. The evaluation results show that the actor who fulfils this role should be independent, trustworthy and transparent. It is not evident who should fill in this role, while multiple options are still open. It could be a representative organisation of prosumer communities (e.g. cooperative of cooperatives), a commercial business, or a company from the energy domain, or possibly a public-private cooperation model. Further research is needed to investigate this role, next to the elaboration of a business model for the prosumer community shopping mall.[37]

3) **Evaluation in the maturity phase**
We studied the development of prosumer communities in their start-up and emerging growth phase. In due course, when prosumer communities actually have reached the maturity phase, it would be interesting to evaluate to which extent the shopping mall has proved to be a suitable solution for prosumer community decision enhancement.

4) **Application to other collective initiatives**
Our research was directed to prosumer communities that primarily focus on energy. Some of the initiatives also incorporate other non-energy related aspects, which we did not explicitly address in the design of our solution. Although the context of operation is different, the similarities with prosumer communities indicate that the shopping mall can also be instantiated for these non-energy related collective initiatives. The shopping mall could serve as a platform for finding and sharing information and expertise where people are guided in finding what they are looking for. The similarities and differences between the energy related and non-energy related collective initiatives should be investigated in order to determine to what extent the structure and content of the shopping mall artefact should be adapted.

[36] The U.S. Commerce Department's National Institute of Standards and Technology (NIST) and the European Union's (EU) Smart Grid Coordination Group (SG-CG) jointly work on Smart Grid standards development.

[37] Within the European CIVIS project work package 6, possible business models for emerging social decentralized energy are being investigated (see: http://www.civisproject.eu).

References

AgentschapNL. (2010). Kracht uit eigen energie - Gemeenten en lokale duurzame energiebedrijven. Retrieved July, 2012, from http://www.rwsleefomgeving.nl/publish/pages/92583/brochure_kracht_uit_eigen_energie_gemeenten_en_lokale_duurzame_energiebedrijven_lokaal_klimaatbeleid.pdf.

Agora. (2013). *12 Insights on Germany's Energiewende.* Berlin: Agora Energiewende.

Allen, S. R., Hammond, G. P., & McManus, M. C. (2008). Prospects for and barriers to domestic micro-generation: A United Kingdom perspective. *Applied Energy, 85*(6), 528-544.

Basaza, H. A. D. (2012). *A decision enhancement studio for starting a miners enterprise in Uganda*. University of Groningen.

Belhomme, R., Cerero, R., Valtorta, G., & Eyrolles, P. (2011). The ADDRESS project: Developing Active Demand in smart power systems integrating renewables. *Power and Energy Society General Meeting, 2011 IEEE,* 1-8.

Benbasat, I., Goldstein, D. K., & Mead, M. (1987). The case research strategy in studies of Information Systems. *MIS Quarterly,* 369-386.

Bliek, F., van den Noort, A., Roossien, B., Kamphuis, R., de Wit, J., van der Velde, J., & Eijgelaar, M. (2010). PowerMatching City, a living lab smart grid demonstration. *Innovative Smart Grid Technologies Conference Europe (ISGT Europe), 2010 IEEE PES,* 1-8.

Bomberg, E., & McEwen, N. (2012). Mobilizing community energy. *Energy Policy, 51*(0), 435-444.

Bouffard, F., & Kirschen, D. S. (2008). Centralised and distributed electricity systems. *Energy Policy, 36*(12), 4504-4508.

Breidenich, C., Magraw, D., Rowley, A., & Rubin, J. W. (1998). The Kyoto protocol to the United Nations framework convention on climate change. *American Journal of International Law*, 315-331.

Briggs, R. O., De Vreede, G., & Nunamaker Jr, J. F. (2003). Collaboration engineering with ThinkLets to pursue sustained success with group support systems. *Journal of Management Information Systems, 19*(4), 31-64.

Briggs, R. O., & De Vreede, G. (2009). *ThinkLets: building blocks for concerted collaboration.* University of Nebraska, Center for Collaboration Science.

Brundtland, G. H. (1987). *Our Common Future - Report of the World Commission on environment and development.* United Nations.

Charnock, G., & Alexander, R. (2007). *A Practical Toolkit for Communities Aiming for Carbon Neutrality.* Ashton Hayes: University of Chester.

Damsté, H., Bongaerts, M., Corton, P., Hoegaerden, V. v., Mulder-Pol, M., & Peters, J. (2011). *Networks for the future - an exploratory study.* Netbeheer Nederland.

Devine-Wright, P., Walker, G., Hunter, S., High, H., & Evans, B. (2007). An empirical study of public beliefs about community renewable energy projects in England and Wales. *Manchester: Manchester Architecture Research Centre, School of Environment and Development*.

Devine-Wright, P. (2009). Rethinking NIMBYism: The role of place attachment and place identity in explaining place-protective action. *Journal of Community & Applied Social Psychology, 19*(6), 426-441.

Duijvestein, C. (1996). *Trias Energetica (strategy)*. Delft University of Technology.

Dutch Government. (2013). *Troonrede 2013*. Amsterdam: Binnenlands Bestuur.

Egyedi, T. M., Mehos, D. C., & Vree, W. G. (2012). Introducing Inverse Infrastructures. In T. M. Egyedi, & D. C. Mehos (Eds.), *Inverse Infrastructures - Disrupting Networks from Below* (pp. 1-16). Cheltenham: Edward Elgar Publishing Limited.

Elzenga, H., & Schwencke, A. M. (2014). *Energiecoöperaties: ambities, handelingsperspectief en interactie met gemeenten - De energieke samenleving in praktijk.* (No. PBL-publicatienummer: 1371). Planbureau voor de Leefomgeving.

Fischer, C., & Sauter, R. (2004). Users as pioneers: Transformation in the electricity system, microCHP and the role of the users. *Proceedings Berlin Conference on Human Dimensions of Global Environmental Change,* 319-337.

Flowers, P. (2009). Research philosophies–importance and relevance. *European Journal of Information Systems, 3*(2), 112-126.

Forrest, N., & Wiek, A. (2014). Learning from success - Toward evidence-informed sustainability transitions in communities. *Environmental Innovation and Societal Transitions, 12*, 66-88.

Frieling, M. A., Lindenberg, S. M., & Stokman, F. N. (2014). Collaborative Communities Through Coproduction - Two Case Studies. *The American Review of Public Administration, 44*(1), 35-58.

Galliers, R. (1992). *Information systems research: Issues, methods and practical guidelines.* Blackwell Scientific.

Geelen, D. V. (2014). *Empowering end-users in the energy transition: An exploration of products and services to support changes in household energy management*. Delft University of Technology.

Gerdes, J., Marbus, S., & Boelhouwer, M. (2014). *Energietrends 2014.*(No. ECN-O--14-041). ECN, Energie-Nederland & Netbeheer Nederland.

González, R. A. (2010). *A framework for ICT-supported coordination in crisis response.* Delft University of Technology.

Gonzalez, R. A., & Sol, H. G. (2012). Validation and design science research in information systems. *Research Methodologies, Innovations and Philosophies in Software Systems Engineering and Information Systems. IGI Global*, 403-426.

Gregor, S., & Hevner, A. R. (2013). Positioning and presenting design science research for maximum impact. *MIS quarterly*, *37*(2), 337-355.

Grijalva, S., & Tariq, M. U. (2011). Prosumer-based smart grid architecture enables a flat, sustainable electricity industry. *Innovative Smart Grid Technologies (ISGT), 2011 IEEE PES,* 1-6.

Griskevicius, V., Cantú, S. M., & Vugt, M. v. (2012). The evolutionary bases for sustainable behaviour: Implications for marketing, policy, and social entrepreneurship. *Journal of Public Policy & Marketing, 31*(1), 115-128.

Haar, I. T., Stijkel, A., Westendorp, P., & Zomer, I. (2011). *P-NUTS, Lokale Duurzame Energie in Nederland: Wij maken het nog mee!*. Amsterdam: NEWNRG.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly, 28*(1), 75-105.

Hevner, A. R. (2007). The three cycle view of design science research. *Scandinavian Journal of Information Systems, 19*(2), 87.

Hevner, A., & Chatterjee, S. (2010). Design science research in information systems. *Design Research in Information Systems* (pp. 9-22). Springer.

Hielscher, S., Seyfang, G., & Smith, A. (2013). Grassroots innovations for sustainable energy: exploring niche development processes among community energy initiatives. *Innovations in Sustainable Consumption: New Economics, Socio-technical Transitions, and Social Practices, Cheltenham, Edward Elgar Publishing*, 133-158.

Holmström, J., Ketokivi, M., & Hameri, A. P. (2009). Bridging practice and theory: a design science approach. *Decision Sciences, 40*(1), 65-87.

Hoogma, R., Kemp, R., Schot, J., & Truffer, B. (2002). *Experimenting for sustainable transport: the approach of strategic niche management*. London: Taylor & Francis.

Houwelingen, P. v., Boele, A., Dekker, P. (2014). Burgermacht op eigen kracht? Een brede verkenning van ontwikkelingen in burgerparticipatie. Sociaal en Cultureel Planbureau, The Hague.

Huijben, J., & Verbong, G. (2013). Breakthrough without subsidies? PV business model experiments in the Netherlands. *Energy Policy, 56*, 362-370.

ICA. (n.d.). *International Co-operative Alliance - Co-operative values*. Retrieved October 26, 2012, from http://ica.coop/.

Jamieson, S. (2004). Likert scales: how to (ab)use them. *Medical Education, 38*(12), 1217-1218.

Jawahar, I., & McLaughlin, G. L. (2001). Toward a descriptive stakeholder theory: An organizational life cycle approach. *Academy of Management Review, 26*(3), 397-414.

Karnouskos, S. (2011a). Communityware smartgrid. *21st International Conference and Exhibition on Electricity Distribution (CIRED 2011), Frankfurt, Germany,* 6-9.

Karnouskos, S. (2011b). Future smart grid prosumer services. *2nd IEEE PES International Conference and Exhibition on Innovative Smart Grid Technologies (ISGT Europe), 2011,* 1-2.

Katumba, P. M. (2015). *A Decision Enhancement Studio for Water Asset Management*. University of Groningen.

Keen, P. G. W., & Sol, H. G. (2008). *Decision enhancement services: rehearsing the future for decisions that matter.* IOS Press.

Khan, M., Chhetri, A., & Islam, M. (2007). Community-based energy model: a novel approach to developing sustainable energy. *Energy Sources, Part B, 2*(4), 353-370.

Knol, A. J. (2013). *Decision Enhancement for Sourcing & Sharing in the Dutch Government*. University of Groningen.

Kobus, C. B., Mugge, R., & Schoormans, J. P. (2015). Long-term influence of the design of energy management systems on lowering household energy consumption. *International Journal of Sustainable Engineering, 8*(3), 173-185.

Kok, J. K., Scheepers, M. J. J., & Kamphuis, I. G. (2010). Intelligence in electricity networks for embedding renewables and distributed generation. *Intelligent infrastructures* (pp. 179-209). Springer.

Kok, K., Karnouskos, S., Ringelstein, J., Dimeas, A., Weidlich, A., Warmer, C., Lioliou, V. (2011). Field-testing smart houses for a smart grid. *21st International Conference and Exhibition on Electricity Distribution (CIRED 2011), Frankfurt, Germany,* 6-9.

Kok, K. (2013). *The PowerMatcher: Smart coordination for the smart electricity grid.* University of Amsterdam.

Kolfschoten, G. L., & Vreede, G. J. d. (2009). A Design Approach for Collaboration Processes: A Multimethod Design Science Study in Collaboration Engineering. *Journal of Management Information Systems, 26*(1), 225-256.

Lattemann, C., & Stieglitz, S. (2005). Framework for governance in open source communities. In *Proceedings of the 38th annual Hawaii international conference on system sciences* (pp. 192-202). IEEE.

Lely, P., Velthuijs, R., & Beuker, H. (2012). *People in Power - De rol van de consument in de toekomst centraal.* (No. HG00148 - 14). Hanze University of Applied Sciences Groningen.

Lindenberg, S., & Foss, N. J. (2011). Managing joint production motivation: The role of goal framing and governance mechanisms. *Academy of Management Review, 36*(3), 500-525.

Loorbach, D., & Rotmans, J. (2010). The practice of transition management: Examples and lessons from four distinct cases. *Futures, 42*(3), 237-246.

Meadows, D. H., Meadows, D. L., Randers, J., & Behrens, W. W. (1972). The limits to growth. *New York, (102).*

Melo, H., & Heinrich, C. (2011). Energy balance in a renewable energy community. *10th International Conference on Environment and Electrical Engineering (EEEIC), 2011,* 1-4.

Mercurio, A., Di Giorgio, A., & Quaresima, A. (2012). Distributed Control Approach for Community Energy Management Systems. *Control & Automation (MED), 2012 20th Mediterranean Conference On,* 1265-1271.

Midden, C. J., Kaiser, F. G., & Teddy McCalley, L. (2007). Technology's four roles in understanding individuals' conservation of natural resources. *Journal of Social Issues, 63*(1), 155-174.

Mulder, W., Kumpavat, K., Faasen, C., Verheij, F., & Vaessen, P. (2012). Global Inventory and Analysis of Smart Grid Demonstration Projects. *DNV KEMA, Arnhem.*

Muniafu, S. M. (2007). *Developing ICT-enabled Services in Transition Countries: a studio-based approach for logistics brokering*. Delft University of Technology.

Musall, F. D., & Kuik, O. (2011). Local acceptance of renewable energy—A case study from southeast Germany. *Energy Policy, 39*(6), 3252-3260.

Netten, T. I. (2010). *Op weg naar intelligente netten in Nederland – Discussiedocument van de Taskforce Intelligente Netten*. Den Haag, Ministerie van Economische Zaken.

Netten, T. I. (2011). *Op weg naar intelligente netten in Nederland – Einddocument van de Taskforce Intelligente Netten*. Den Haag, Ministerie van Economische Zaken.

Orlikowski, W. J., & Baroudi, J. J. (1991). Studying information technology in organizations: Research approaches and assumptions. *Information Systems Research, 2*(1), 1-28.

Ostrom, E., 2009. A general framework for analyzing sustainability of social–ecological systems. *Science, 325*(5939), 419-422.

Pagani, G. A., & Aiello, M. (2010). Towards a service-oriented energy market: current state and trend. In *International Conference on Service-Oriented Computing* (pp. 203-209). Springer Berlin Heidelberg.

Palm, J., & Tengvard, M. (2011). Motives for and barriers to household adoption of small-scale production of electricity: examples from Sweden. *Millennium Consumption Goals: A Fair Proposal from the Poor to the Rich, 7*(1), 6.

Parker, F. E., & Cowan, H. I. (1944). *Cooperative associations in Europe and their possibilities for post-war reconstruction* (Vol. 770). US Government Printing Office.

Passey, R., Spooner, T., MacGill, I., Watt, M., & Syngellakis, K. (2011). The potential impacts of grid-connected distributed generation and how to address them: A review of technical and non-technical factors. *Energy Policy, 39*(10), 6280-6290.

Peffers, K., Tuunanen, T., Rothenberger, M., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems, 24*(3), 45-77.

Peine, A. (2008). Technological paradigms and complex technical systems—the case of smart homes. *Research Policy, 37*(3), 508-529.

Power, D.J. (2007). *A Brief History of Decision Support Systems.* DSSResources.COM, World Wide Web, http://DSSResources.COM/history/dsshistory.html, version 4.0, March 10, 2007.

Pront-van Bommel, S. (2012). *Een redelijke energieprijs - De mythe van de marktwerking*. University of Amsterdam.

Ramesh, R., & Rao, H. R. (2005). Foreword Design Science and Information Systems. *Information Systems Frontiers, 7*(3), 215-215.

Rathnayaka, A. D., Potdar, V. M., Hussain, O., & Dillon, T. (2011). Identifying prosumer's energy sharing behaviours for forming optimal prosumer-communities. *International Conference on Cloud and Service Computing (CSC), 2011,* 199-206.

Rijksoverheid, D. (2011). *Klimaatbrief 2050-Uitdagingen voor Nederland bij het streven naar een concurrerend, klimaat-neutraal Europa.* The Hague, Ministery of Infrastructure and Environment.

Ritzer, G., Dean, P., & Jurgenson, N. (2012). The coming of age of the prosumer. *American Behavioral Scientist, 56*(4), 379-398.

Roadmap (2011). 2050. Communication from the Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions. COM (2011) 885/2. *Brussels: European Commission.*

Rogers, E. M. (1995). *Diffusion of innovations*. New York: Free Press.

Ros, J., Koelemeijer, R., Elzenga, H., Peters, J., & Hekkenberg, M. (2011). *Towards a clean economy in 2050 - An outline of roads. How the Netherlands can become climate -neutral.* The Hague, Netherlands, Planbureau voor de Leefomgeving PBL.

Rotmans, J., & Horsten, H. (2012). *In het oog van de orkaan: Nederland in transitie*. Boxtel: Aeneas.

Rydin, Y., Turcu, C., Guy, S., & Austin, P. (2013). Mapping the co-evolution of urban energy systems: pathways of change. *Environment and Planning A: International Journal of Urban and Regional Research, 45*(3), 634-649.

Saunders, M. N., Saunders, M., Lewis, P., & Thornhill, A. (2011). *Research Methods For Business Students* (5th ed.). Pearson Education India.

Sauter, R., & Watson, J. (2007). Strategies for the deployment of micro-generation: Implications for social acceptance. *Energy Policy, 35*(5), 2770-2779.

Schwencke, A. M. (2012). *Energieke Bottomup in Lage Landen - De Energietransitie van Onderaf.* Leiden: AS I-Search.

Schwencke, A. M., van der Steenhoven, M., & Wendel, A. (2013). *De Proeftuin Decentrale Duurzame Collectieven. Van realisatie naar de toekomst. Eindrapportage Netbeheer Nederland Onderzoek Decentrale Markten.* Netbeheer Nederland.

Schwencke, A. M. (2016). *Lokale Energie Monitor 2016.* RVO.nl. Retrieved November, 2016, from http://www.hieropgewekt.nl/lokale-energie-monitor.

Seligmann, P. S., Wijers, G. M., & Sol, H. G. (1989). Analyzing the structure of IS methodologies, an alternative approach. In *Proceedings of the First Dutch Conference on Information Systems* (pp. 1-2). Amersfoort, The Netherlands.

SER. (2013). *Energieakkoord voor duurzame groei.* Den Haag: Sociaal Economische Raad.

Seyfang, G., & Smith, A. (2007). Grassroots innovations for sustainable development: Towards a new research and policy agenda. *Environmental Politics, 16*(4), 584-603.

Seyfang, G., Park, J. J., & Smith, A. (2013). A thousand flowers blooming? An examination of community energy in the UK. *Energy Policy, 61*, 977-989.

Shandurkova, I., Bremdal, B., Bacher, R., Ottesen, S., & Nilsen, A. (2012). *A Prosumer Oriented Energy Market. Developments and future outlooks for Smart Grid oriented energy markets.* NCE Smart Energy Markets, Halden.

SmartGrids (2012). *SmartGrids SRA 2035 - Strategic Research Agenda Update of the SmartGrids SRA 2007 for the Needs by the Year 2035.* European Union, Brussels.

Sol, H. G. (1982). *Simulation in Information Systems Development*. University of Groningen.

Sol, H.G. (1988). Information systems development: a problem solving approach. *Proceedings of 1988 INTEC symposium, systems analysis and design: A research strategy*. Atlanta.

Sol, H.G. (1991). Information systems to support decision processes. In Sol, H.G; Vecsenyi, J. (Eds.), *Environments for Supporting Decision Processes* (pp. 115-127). Proceedings of the IFIP WG 8.3 Working Conference on Environments for Supporting Decision Processes. Budapest, Hungary, 18-21 June 1990. Amsterdam: Elsevier Science Publishers B.V.

Staatsblad. (2013). *Wet van 18 december 2013 tot wijziging van enkele belastingwetten en enige andere wetten*. Den Haag: Koninkrijk der Nederlanden.

Steg, L. (2008). Promoting household energy conservation. *Energy Policy, 36*(12), 4449-4453.

Steinheimer, M., Trick, U., & Ruhrig, P. (2012). Energy communities in Smart Markets for optimisation of peer-to-peer interconnected Smart Homes. *8th International Symposium on Communication Systems, Networks & Digital Signal Processing (CSNDSP), 2012,* 1-6.

Stokman, F. N. (2011). Citizens as (co-)producer. *14th Economics of Infrastructures Conference - Entrepreneurship and Regulation in Infrastructure.* Delft University of Technology.

Straathof, I., Coenders, M., & Saris, J. (2012). *Lokale duurzame energie bedrijven - Negen lessen van de Community of Practice,* (e-book No. 2FLOK1212). Utrecht: Agentschap NL.

Ten Donkelaar, M., & Scheepers, M. J. (2004). A socio-economic analysis of technical solutions and practices for the integration of distributed generation. *DISPOWER Project Report (Ref.ECN-C-04-011.Petten), the Netherlands,* 72-73.

Timmerman, W.H., & Huitema, G. (2009). Design of Energy-Management Services–Supporting the Role of the Prosumer in the Energy Market. *CAiSE-DC*, *9*, 9-10.

Timmerman, W.H. (2014). Providing Energy Management Services to Prosumer Communities. *ESEIA-IGS Conference Smart and Green Transitions in Cities / Regions*, 24-25 April 2014, Enschede, The Netherlands.

Timmerman, W.H. (2015). Prosumer community exploratory study and evaluation: research data and analysis - Thesis appendix report. Hanze University of Applied Sciences Groningen.

Toffler, A., Longul, W., & Forbes, H. (1981). *The third wave.* Bantam books, New York.

Trochim, W. M. K., James, P., & Donnelly, J. P. (2001). *Research Methods Knowledge Base*. Ohio: Thomson.

UN. (n.d.). International Year of Cooperatives 2012. Retrieved October 26, 2012, from http://social.un.org/coopsyear/.

UNFCCC (2015). *Adoption of the Paris Agreement*. Paris: United Nations Framework Convention on Climate Change.

Vaishnavi, V. K., & Kuechler Jr, W. (2007). *Design science research methods and patterns: innovating information and communication technology*. New York: Auerbach Publications.

Van Dril, T., Gerdes, J., Marbus, S., & Boelhouwer, M. (2102). *Energietrends 2012.* ECN, Energie-Nederland & Netbeheer Nederland.

Van Oorschot, K., De Hoog, J., Van Der Steen, M., & Van Twist, M. (2013). The three pillars of the co-operative. *Journal of Co-operative Organization and Management, 1*(2), 64-69.

Verbong, G., & Geels, F. (2007). The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). *Energy Policy, 35*(2), 1025-1037.

Verbong, G. P. J., & Geels, F. W. (2010). Exploring sustainability transitions in the electricity sector with socio-technical pathways. *Technological Forecasting and Social Change, 77*(8), 1214-1221.

Verbong, G. P. J., Beemsterboer, S., & Sengers, F. (2012). Smart grids or smart users? Involving users in developing a low carbon electricity economy. *Energy Policy, 52*, 117-125.

Villinger, A., Wüstenhagen, R., & Meyer, A. (2000). *Jenseits der Öko-Nische* (1st ed.). Springer-Verlag.

Vogt, H., Weiss, H., Spiess, P., & Karduck, A. P. (2010). Market-based prosumer participation in the smart grid. *4th IEEE International Conference on Digital Ecosystems and Technologies (DEST),* 592-597.

Walker, G., Devine-Wright, P., & Evans, B. (2006). Embedding socio-technical innovation? Niche management and community-based localism in renewable energy policy in the UK. *Proceedings of the Future of Science, Technology and Innovation Policy Conference.*

Walker, G., & Cass, N. (2007). Carbon reduction, 'the public' and renewable energy: engaging with socio-technical configurations. *Area, 39*(4), 458-469.

Walker, G., Hunter, S., Devine-Wright, P., Evans, B., & Fay, H. (2007). Harnessing community energies: explaining and evaluating community-based localism in renewable energy policy in the UK. *Global Environmental Politics, 7*(2), 64-82.

Walker, G. (2008). What are the barriers and incentives for community-owned means of energy production and use? *Energy Policy, 36*(12), 4401-4405.

Walker, G., & Devine-Wright, P. (2008). Community renewable energy: What should it mean? *Energy Policy, 36*(2), 497-500.

Warren, C. R., & McFadyen, M. (2010). Does community ownership affect public attitudes to wind energy? A case study from south-west Scotland. *Land use Policy, 27*(2), 204-213.

Watson, J. (2004). Co-provision in sustainable energy systems: the case of micro-generation. *Energy Policy, 32*(17), 1981-1990.

Watson, J., Sauter, R., Bahaj, A., James, P., Myers, L., & Wing, R. (2006). Unlocking the Power House: Policy and system change for domestic micro-generation in the UK.

Watson, J., Sauter, R., Bahaj, B., James, P., Myers, L., & Wing, R. (2008). Domestic micro-generation: Economic, regulatory and policy issues for the UK. *Energy Policy, 36*(8), 3095-3106.

Wieringa, R. J. (2014). *Design science methodology for information systems and software engineering*. Springer.

Wolsink, M. (2012). The research agenda on social acceptance of distributed generation in smart grids: Renewable as common pool resources. *Renewable and Sustainable Energy Reviews, 16*(1), 822-835.

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. Energy Policy, 35(5), 2683-2691.

Appendix 1: Regulatory issues concerning prosumer communities

White label construction for local energy supply

Until the end of 2012 many Dutch prosumer communities made use of the so-called *white label construction* for energy supply to their customers. A white label construction implicates that the energy supply is organised via a third party retailer, who owns a supply permit. The third party takes care of the energy purchase on the Dutch Amsterdam Power Exchange (APX), as well as all related back office activities, such as program responsibility and billing. The prosumer communities could use their own brand and label in the correspondence towards their customers, as if the prosumer community itself was the retailer. Furthermore, the customer database was owned by the cooperative, and not by the third party. Prosumer communities bargained with the retailer on the energy price for their customers, as well as on the fee for the prosumer community organisation. This way the prosumer community could generate revenues that could be employed for local sustainable investments. Prosumer communities chose the white label construction as an intermediate solution. Ultimately they want to apply for a supply permit themselves, at the moment when a large enough customer base is reached.

In December 2012 one of the main Dutch white label providers, Trianel, went bankrupt. This posed a large (financial) pressure on the prosumer communities that dealt with Trianel. Energy supply is guaranteed by law, so the customers themselves did not run the risk of being cut off of energy. Furthermore, the bankruptcy was the immediate cause for the Dutch competition supervisor (ACM – Authority for Consumers & Markets) to take action: they forbid the white label construction. According to the ACM this construction did not comply with the law, while the energy price setting of the white label provider was not transparent to customers. The ACM offered the afflicted prosumer communities two alternative solutions: 1) to become a reseller, by transferring their customers to a retailer, who owns a supplier permit, or 2) to apply for a supply permit themselves. The reseller construction is much more transparent to customers than the white label construction. Each of the involved prosumer communities has chosen its own solution.

Stimulation regulations on sustainable energy production

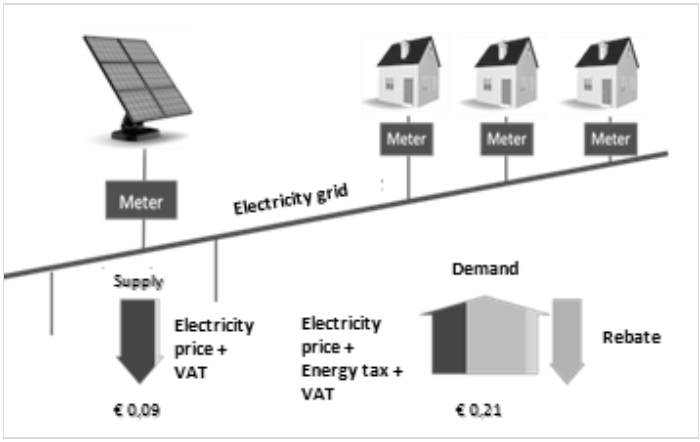
Net metering

To stimulate private investments in sustainable energy generation for small-scale consumers (i.e. grid connection smaller than 3x80 Ampere), the Dutch authorities introduced the so-called *salderingsregeling*[38]. This means that when a house owner installs PV panels at his own rooftop (*behind the meter*) the surplus of electricity that is delivered back to the grid, can be fully deducted (retail pricing, including energy taxes and VAT) from the energy, which is used from the grid at times when the demand is larger than the momentary own production. The deduction is limited to the amount of energy that has been delivered from the retailer. The net metering is settled via the bill of the retailer. The regulation is only applicable for house owners, whereas the rooftop has to be suitable for solar panel installation, which in practice means that only 15% of the total Dutch housing stock is qualified for this arrangement.

Postal code regulation

In January 2014, new legislation was introduced for collective energy projects. Members of a cooperative and members of a home owner association (VVEs), are eligible for a tax deduction of 0,075 €/kWh[39] for their collectively generated sustainable energy[40], given that members have a small-consumer connection (maximum of 3x80A) (Staatsblad, 2013). The tax deduction is settled via the energy bill of each of the participants, up to a maximum of 10.000 kWh per year. The generation facility can be a solar panel field, or a set of roof top solar panels on a block of flats. It is called the *postal code rose regulation*, while only those residents can apply, who live in the same or neighbouring postal code area (first four numbers), next to the postal code area where the generation facility resides. Figure 25 below shows the rebate construction, as well as the postal code rose construction.

[38] See website Rijksoverheid.nl: https://www.rijksoverheid.nl/onderwerpen/duurzame-energie/inhoud/zonne-energie. Last accessed 3 May 2016.
[39] When VAT is included, the tax deduction is € 0,09 €/kWh.
[40] Since 1 January 2016 this tax deduction is raised to 0,09 €/kWh.



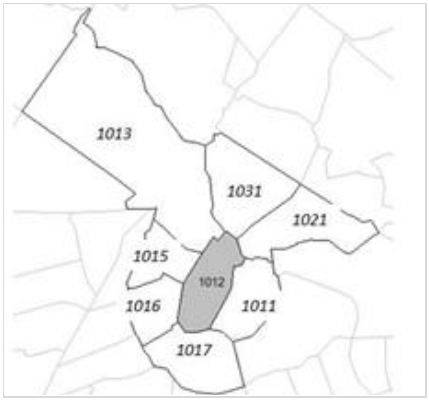


Figure 25: Tax deduction rebate scheme[41] and Postal code rose construction[42]

SDE+

The SDE+ (Stimulating Sustainable Energy production) regulation can be used by companies and (non-profit) institutions who (want to) produce sustainable energy[43]. The regulation compensates for the higher cost price of sustainable energy generation in comparison to fossil fuel based generation. Depending on which sustainable energy technique is being used (e.g. biomass, solar, geothermal, wind, water), different categories and subsidies are applicable.

[41] Courtesy to http://www.wijkenergie.coop
[42] Courtesy to http://www.zonnepanelen.net/postcoderoos/
[43] See website Rijksoverheid.nl: http://www.rvo.nl/subsidies-regelingen/stimulering-duurzame-energieproductie-sde. Last accessed 3 May 2016

Appendix 2: Topic list case study interviews

No	Topics
1.	When was the initiative started and who were involved?
2.	Which goals have been set?
3.	What is the business plan of your initiative?
4.	What is the current status?
5.	Are you planning to opt for a supply permit?
6.	What are the plans for the short term and long(er) term?
7.	What is the role of intermediary parties for your initiative?
8.	Which technology developments do you see that are relevant for the development of local energy initiatives?
9.	What would be the requirements for supportive ICT services?
10.	How do you see the division of roles in the energy value network of prosumer communities?
11.	Which developments do you see that are relevant for your initiative?
12.	What other initiatives are you familiar with and what is your relationship with them?
13.	Who else do you recommend I definitely should speak with?

Appendix 3: Topic list stakeholder interviews

No	Topics
1.	How do you position your company/organization in the current energy market?
2.	Which specific services do you offer to end users/prosumers?
3.	How do you value the role of consumers as generators and suppliers of energy?
4.	What is your vision on what prosumers require for controlling and managing their own energy generation and consumption?
5.	Do you think of specific services?
6.	Do you believe in a future open market place where individual prosumers, or communities of prosumers offer and purchase their energy?
7.	What is your opinion on autarkic units (self-supportive households, neighbourhoods, villages, towns, regions)?
8.	What do you consider to be the highest barrier the development of prosumer communities?
9.	How do you see the role of non-traditional parties that are now (trying to) enter the energy market?
10.	Which role do you foresee for the multinational ICT companies like Microsoft, Google and Intel on the energy market?
11.	Which role do you (fore)see for intermediate parties like e-Decentraal, SET, VEC, etc.?
12.	What will be the future role for the traditional energy companies like grid operators and retailers?
13.	Regarding service development and innovations, the following questions: - How is your service development/innovation process organised? - Who/which departments are involved? - Which methodologies do you use? - To what extent are end-users involved in the service development/innovation process, in which way, and when

No	Topics
14.	What do you consider to be the most important (technological) developments for the energy sector, and why?
15.	How relevant are the following technological developments, and why/why not? - smart meters - smart grids - smart homes - smart appliances - smart customers - smart anything/Internet of Things
16.	Which pilot project are active or planned within your company/organisation
17.	Do you see opportunities for my research to link up with one of your (pilot) projects
18.	Famous last question: who else do you recommend I definitely should speak with?

Appendix 4: List of stakeholder interviews

No	Date	Interviewee	Organisation
1.	25-9-2007	Joop Volkers	Energy Valley
2.	5-10-2007	Harold Veldkamp	TNO
3.	8-10-2007	Chris Ijsbrandy	UCPartners
4.	10-10-2007	Nick Szirbik	University of Groningen
5.	14-11-2007	Martijn Bongaerts	Continuon/Liander
6.	6-12-2007	Ferry Cserép	Netinium
7.	17-12-2007	René Kamphuis	ECN
8.	27-3-2008	Hans Wortmann	University of Groningen
9.	16-10-2008	Jeroen de Beer	Ecofys
10.	17-11-2008	Frans Campfens	NUON/Liander
11.	11-12-2008	Alex Bouw	IBM
12.	12-5-2009	Hilbrand Does	Oxxio
13.	9-6-2009	Gory Lambregts Paul Hermans	NUON
14.	16-7-2009	Frans Stokman	University of Groningen
15.	14-10-2009	Paul Hermans	NUON
16.	13-11-2009	Han Slootweg	Enexis – TU Eindhoven
17.	18-1-2010	Anne Stijkel	Stichting Triple I-S
18.	9-2-2010	Bindert Kloosterman	Noordenwind
19.	1-6-2010	Igor Kluin	Qurrent
20.	22-7-2010	Ylva Poellman	Thomsonstraat Groningen
21.	20-9-2010	Hans Overdiep	GasTerra
22.	21-9-2010	Els van der Kar	TU Delft
23.	4-11-20100	Daphne Geelen	TU Delft
24.	9-12-2010	Wil van Paridon	Metsens
25.	10-2-2011	Ruud de Bruijne	Agentschap.nl/RVO
26.	20-4-2011	Paul Hermans	AurumEurope
27.	21-4-2011	Mijntje de Caluwé	Essent
28.	28-4-2011	Martijn Bongaerts	Liander
29.	29-4-2011	Johan Kiewiet	Amelander Energie Coöperatie U.A.
30.	29-4-2011	Frans Wieringa	Zoneco, SDOE
31.	29-4-2011	Peter van Vliet	ZonVogel

No	Date	Interviewee	Organisation
32.	3-5-2011	Bindert Kloosterman	Noordenwind
33.	9-5-2011	Grietha de Boer	Thomsonstraat Groningen
34.	10-5-2011	Jan Schouw	RElocal
35.	11-5-2011	Bas Waldekker	Greenchoice
36.	12-5-2011	Henri ter Hofte	ZET Zutphen aan Zet
37.	12-5-2011	Adri Ros	Zonnehoven Deventer
38.	20-5-2011	Wil van Paridon	Metsens
39.	1-6-2011	Ruut Schalij Thomas Kruithof	Eemflow Energy
40.	14-6-2011	Nick Waltmans	Trianel
41.	13-9-2011	Albert van der Noort	KEMA/DNV GL
42.	15-9-2011	Frens Jan Rumph	TNO
43.	27-9-2011	Jacob Mulder	Logica
44.	24-7-2012	Henk Koopmans	Stichting Energietransitie Nederland (SET.nl)
45.	21-3-2012	Louis Godschalk	Zeenergie
46.	30-3-2012	Marten Tilstra	Province Flevoland
47.	30-10-2012	Frans Stokman	University of Groningen
48.	30-10-2012	Frans Stokman	University of Groningen
49.	7-12-2012	Koen Kok	ECN-TNO
50.	25-4-12013	Jos Bijkersma	Grunneger Power
51.	31-5-2013	Paul Stolte	LochemEnergie
52.	5-11-2013	René Pie	AllAboutEnergy

52 interviews in total, including multiple interviews with:

- Frans Stokman: 3x
- Paul Hermans: 3x
- Bindert Kloosterman: 2x

Appendix 5: Evaluation task assignment form

You are about to enter the shopping for local energy initiatives. You are welcome!
The tasks described below will lead you through the shopping mall, step by step. The aim of the task assignment is to give you a good overview of which functionalities the shopping mall has to offer.
The language used in the shopping mall is English. Whenever the terminology is not clear, please do not hesitate to ask the facilitator for clarification. During the assignment you have to switch roles back and forth a number of times: from **manager of an initiative**, to **member**, and **service provider**. Therefore you have to log in and log out a number of times.

Do you have any questions, please feel free to ask. Success and pleasure with your shopping mall experience!

URL prototype: **http://26fsu4.axshare.com/home.html**

Task 1 – Registration

⇨ Register at the prosumer community shopping mall and create an account. You can choose yourself whether you want to register as a community manager or as community member.
You do not need to fill in all the fields.

Task 2 – Log in as community manager

⇨ You are now registered. Congratulations!
Now log in at the shopping mall as a community manager, and take your time to look around which shops and services are being offered.
Fill in fields:

⇨ Username: manager1
Password: -

Task 3 – Start-up a local initiative

As a starting initiative you are looking for information and examples that can help you to give form to your initiative.

- ⇨ Look up information for starting-up a local initiative.
  - Collect the information that is necessary for setting up a business model.
  - Examine which are the options for a local initiative for energy supply

Task 4 – Community energy management dashboard

As operational manager if a local energy initiative you would like to have insight as well an overview of everything that goes on within the community. Therefore you need an energy management system, which provides you with a dashboard, giving you overview and control on the various active energy generators and energy consumers, and the related energy streams.

- ⇨ Go to the shopping mall and look up the service Community Energy Management System, and order it.
  Do not go the cash register yet!! *(click on Other services)*

Task 5 – Organise a PV park

As local initiative your objective is to generate as much as possible your own sustainable energy. Therefore your cooperation decided to start an energy project in order to establish a solar panel park on an unoccupied part of the local industrial zone. The municipality already promised her full cooperation. You also want to make use of the postal code subsidy scheme.

- ⇨ Sort out which local installer companies are available, as part of your project organisation, that could take care of the installation and the control of the PV park energy project.
- ⇨ Apply for the certificates of origin (GVO) at the authority in charge (Certiq).
- ⇨ Check whether there is a grid connection available at the concerned address and if so which kind of connection it is.
- ⇨ I fit is not the appropriate grid connection, and then request one at the local grid operator.

Task 6 – Add new service as a service provider

In the shopping mall you find various shops, each with a large collection of services. These services are developed and provided by various parties, the

service providers. The mall facilitator organizes the placement of new services in one or more shops. We now will walk through this process.

- ⇨ Log out as community manager.
  You now return the main start page of the shopping mall.
- ⇨ Now log nu service provider
  Fill in fields:

⇨ Username: SP1 Password: -

- ⇨ Now you are on the page of service provider. You developed a new service, called "**Weather forecast**", which generates a production forecast, for solar panels and wind mills within your community, based on the local weather forecast.
- ⇨ The description of the service is already filled in for you. You can now upload the service to the shopping mall. Watch the process as it goes. When it is finished, you can log out again. You are back on the main start page of the shopping mall.

Task 7 – New service available!

As a local initiative you are constantly developing, looking ahead to the next steps that have be taken. To support you in that development process, the shopping mall will continuously update her assortment of shops and services.

- ⇨ Now log in as a community manager, but now with a different username!!
  Fill in fields:

⇨ Username: member2 Password: -

- ⇨ Now you can see that there is a new service available, which can be very interesting for your local initiative.

Task 8 –Log in as member

Now you are logged in as a manager of a local initiative. Please log out, and you will return to the main start page of the shopping mall

- ⇨ Now log in as a member of a local initiative.
  Fill in fields:

⇨ Username: member1 Password: -

Take your time to look around which shops and services are being offered on your member start page.

⇨ Click on My profile. Do you have solar panels, or not?

Task 9 – Home energy management

As an individual member you like to have insight and overview of what is happening in your own house. Therefore you need an energy management system, which provides a dashboard for monitoring and controlling the various components in your house.

⇨ Go back to the shopping mall, look up and order the service Home Energy Management System.
Do not go the cash register yet!! *(click on Other services)*

Task 10 –Smart washing machine

Your washing machine was broken, and you bought a smart washing machine. You really want your washing machine to operate in a smart way, so the laundry is done at the most favourable moment. For instance, when it is a sunny or windy day, and your own solar panels or wind mills, or the ones within your community, amply produce green energy. To realise that, your washing machine needs to communicate with your home energy management system.

⇨ Go to shopping mall, find and order the smart washing machine service.
Do not go the cash register yet!! *(click on Other services)*

Task 11 – Electric car

Your car also needed to be replaced. While you are environment-minded, you decided to purchase an electric. Lucky you, you could also make use of favourable subsidy scheme! The mileage you make for your daily work and private routine means that the battery only needs to be charged once every two days. You preferably want to that as smart as possible, when for instance the electricity price is low. You need an app for that.

⇨ Go to shopping mall, find and order the smart EV charging service.
Do not go the cash register yet!! *(click on Other services)*

Task 12 – Bill settlement

You already ordered several services and put them in your shopping cart. It's enough for now, time for paying the bill.

⇨ Go to your Shopping cart and choose the payment method.

Task 13 –My dashboard

You have now selected and purchased several services. It's time to look at the services that are now downloaded and installed at your own system.

⇨ Go to My dashboard and click on the icons off the various services. A pop-up will appear, showing you how the service looks like and which functionalities it offers.

Close the browser page of My dashboard.

⇨ ***Task 14 – Log in as member with a different profile***

First, log out again. You are back on the main start page of the shopping mall. Now log in as a member from the same prosumer community.

⇨ Fill in fields:

⇨ Username: member2 Password: -

⇨ Click on My profile. Do you have solar panels, or not?

Task 15 – Electric car

You were infected by the enthusiasm of your colleague community member Dim Franssen, about his new electric car. You delved into it, and in the meantime you also bought an electric car. Obviously, you also want your car to be charged in a smart way.

⇨ Go back to the shopping mall, and find the smart EV charging service for your new electric car. Select the service.
Pay attention whether there is an attractive alternative service available, and order it!!!

You are finished shopping now. Hopefully you enjoyed it. See you next time!

Appendix 6: Questionnaire Evaluation Shopping Mall Concept

You just participated in the evaluation research of the shopping mall for local energy initiatives. The objective of this questionnaire is to evaluate to which extent **the concept of the shopping mall** is useful for local energy initiatives and their participants in both *the startup phase*, *the emerging growth phase* and *the maturity phase*. The point is ***not*** to evaluate ***the prototype*** *of the shopping mall*, but to evaluate *the shopping mall concept*.

The questionnaire consists of three parts:

1. The first part relates to **the usefulness** of the shopping mall concept. On the basis of a number of statements you can indicate to what extent you agree or disagree with that statement.
2. The second part deals with **usability**.
3. The last part include a number of **open question**, and in the end you will be asked to provide some personal data.

Filling in the questionnaire will take approximately 15 minutes. Your input will be processed completely anonymous.

Indicate per statement to which extent you agree or disagree with the statement. Please carefully read the statement! It can be formulated **positively** or **negatively**!

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

Usefulness quantitative part of the questionnaire

Usefulness

"The extent to which the shopping mall concept is useful and provides support for starting up (start-up phase), the growth (emerging growth phase and maturity phase), and the daily management (operational) of a local energy initiatives"

Usefulness	**Strongly disagree (1)**	**Disagree (2)**	**Neutral (3)**	**Agree (4)**	**Strongly agree (5)**
Start-up phase					
1. The shopping mall provides relevant information and examples for starting-up a local energy initiative					
2. The shopping mall provides **no added value** for the start-up phase, because the information also can be found elsewhere					
Emerging growth phase					
3. The shopping mall provides relevant information and services that support the selection process of local sustainable energy supply					
4. The shopping mall provides relevant information and services that support setting-up a local energy project (e.g. wind mill(s), solar park)					
5. The shopping mall provides services that are useful for member and customer recruitment					

Usefulness	**Strongly disagree (1)**	**Disagree (2)**	**Neutral (3)**	**Agree (4)**	**Strongly agree (5)**
6. The shopping mall provides **no added value** for the growth phase, because the information also can be found elsewhere					
Maturity phase					
7. The shopping mall provides services that are useful for the daily operation of a local energy initiative					
8. The shopping mall provides useful services that support local balancing of energy demand and supply					
In general					
9. Who fulfils the role of the shopping mall facilitator is of **no importance** for the local energy initiative					
10. The shopping mall provides services that are useful for the individual participants of a local energy initiative					
11. The shopping mall provides insight in which services are available for local energy initiatives now and will be available in the future					

Usefulness qualitative part of the questionnaire

12. The top 3 of most important added value that is provided by the shopping mall, is:
    (**1 –** most important; **2** – less important; **3** - important):
    - ☐ All services in one place
    - ☐ Settlement of services in one place
    - ☐ Continuous renewal of the service offering (flexibility)
    - ☐ The service offering is attuned to the personal profile (personalisation)
    - ☐ Interoperability of the services
    - ☐ The services are selected and provided by a trusted party
    - ☐ The shopping mall relieves local energy initiatives
    - ☐ Other, namely .....

Open questions

13. What do you think will be the prerequisites of local energy initiatives for using the shopping mall?
14. What do you think is the added value of the shopping mall concept for local energy initiatives?
15. What do you think are the strongest points of the shopping mall concept?
16. What do you think are the weakest points of the shopping mall concept?
17. Which essential elements are you missing in the shopping mall concept?
18. Furthermore, I would like to add the following:

Usability quantitative part of the questionnaire

Usability

"The extent to which the shopping mall concept is easy to use"

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
Usability					
19. The structure of the shopping mall is clear and logical					
20. The shopping mall is visual attractive					
21. The interface of the shopping mall is clear and easy to use					
22. It is easy to navigate through the shopping mall					
23. The used nomenclature and terminology is clear					
24. The shopping mall provides sufficient feedback during navigation					
Session facilitation					
25. The tasks were clearly formulated and easy to fulfil					
26. In advance it was clear what was expected from me					
27. During the session I experienced sufficient room for personal input					

Demographic data

1. Age category:
   - ☐ Younger than 21 years
   - ☐ 21-30 years
   - ☐ 31-40 years
   - ☐ 41-50 years
   - ☐ 51-60 years
   - ☐ Older than 60 years

2. Gender:
   - ☐ Female
   - ☐ Male
3. Highest level of education
   - ☐ Primary school / secondary school
   - ☐ Secondary vocational education
   - ☐ Higher vocational education
   - ☐ University education

Community session part

4. I am involved in the local energy initiative (name):.....
5. Legal entity of local initiative
   - ☐ Cooperative
   - ☐ Association
   - ☐ Foundation
   - ☐ Ltd
   - ☐ Others, namely …….....
6. My role in local energy initiative (multiple roles possible)
   - ☐ Board
   - ☐ Professional
   - ☐ Volunteer
   - ☐ Member
   - ☐ Customer of the local energy company
   - ☐ Others, namely …….....

Expert session part

4. My work
   a. Organisation name: ……..……
   b. Function .:……..……..
5. Work activitie:s ……..……..……..
6. My relation to local energy initiatives: ……..……..

List of Acronyms and Abbreviations

List of Acronyms and Abbreviations	
ACM	Authority Consumer & Market
APX	Amsterdam Power Exchange
CEMS	Community Energy Management System
CHP	Combined Heat and Power
CIC	Community Interest Company
DSIS	Design Science in Information Systems
DSM	Demand Side Management
DSO	Distribution System Operator
EL&I	Dutch ministry of Economics, Agriculture and Innovation
EMS	Energy Management System
ESCO	Energy Service Company
EV	Electric Vehicle
GSS	Group Support System
HEMS	Home Energy Management System
IPIN	Dutch subsidy program for Innovation Platform for Intelligent Networks
Ltd	Limited company
microCHP	micro Combined Heat and Power
PV	Photo Voltaic
OSI	Open Systems Interconnection reference model
SME	Small and Medium Enterprises
SOA	Service Oriented Architecture
SP	Service Provider
TSO	Transmission System Operator
U.A.	Limited Liability (Dutch)
µCHP	micro Combined Heat and Power
UK	United Kingdom
USP	Unique Selling Point
VVE's	Association of corporate housing apartments (Dutch)

English summary

In the transition towards a sustainable environment the last decade has shown the emergence of numerous local energy communities. In such collective initiatives citizens organize themselves with the aim to establish their own sustainable energy provision at a local level. We speak of *prosumer communities*. For prosumer communities to be successful, a combination of entrepreneurship and energy market and technology knowledge is essential. Therefore, prosumer communities need to be facilitated in order to support them in making the right decisions with respect to the necessary knowledge and expert resources. An integrated concept that covers the full range of decision making along the growth path of prosumer communities is not yet available.

This research focuses on how prosumer communities can be facilitated in their growth path, from incubation towards a mature, self-supporting local energy community. In order to develop proper decision enhancement for prosumer communities, we adopted the design science research philosophy of Hevner and followed the inductive-hypothetic research strategy of Sol, consisting of four different phases: *Exploration, Understanding, Design* and *Evaluation*.

Prior to the exploration phase, a literature review was carried out in order to create a lens from three perspectives on the phenomenon of emerging prosumer communities:

- What are people's motives to start-up a prosumer community or to participate in it?
- How are these initiatives organised in what contextual environments?
- What technological developments are applicable for prosumer communities?

Exploration

The goal of the *Exploration phase* was to get a better view on, and a deeper insight in the development of prosumer communities. An exploratory study was conducted consisting of case studies with prosumer communities, group sessions with individual community participants, and interviews with various stakeholders from the prosumer communities' value network.

The selected prosumer communities for the cases studies TexelEnergie, Grunneger Power, LochemEnergie and Zeenergie, were initiated by citizens and had been active for more than two years. These prosumer communities adopted the legal form of a cooperative with limited liability. The case studies gave us insight in the history of the prosumer communities, their goals and organisational form, and activities they carried out so far (e.g. collective purchase of solar panels, organisation of sustainable energy supply, providing energy advice, etc.), and smart energy services that had been rolled out in the smart grid pilot projects they were participating in. Furthermore, we identified the activities that were planned for the future. The studied prosumer communities all emphasised the importance of their local presence, having a local brand where people could identify themselves with. The contribution to sustainability goals, in combination with the stimulation of social cohesion and local employment, were considered to be important drivers for prosumer communities.

From the group sessions with individual prosumer community participants it appeared that the majority of the participants was driven by both sustainability and economical motives. Moreover, the criteria of trust, control and usability were mentioned as important prerequisites when using automated tools for energy management in a smart grid environment. Furthermore, gaining insight in energy usage and receiving feedback on energy behaviour were indicated as being desirable functionalities.
The stakeholder interviewees represented a variety of actors that play a role in the prosumer communities' value network, including grid operators, retailers, authorities, research and consultancy firms and service providers. The interviewees were asked to give their vision on the future developments in the energy sector, and in particular which role they foresee for prosumer communities. A broad range of subjects was raised in the interviews. Amongst others, the interviewees confirmed the results of the case studies, as they recognised the problems that prosumer communities are facing. It was also indicated that the role of prosumer communities was considered crucial for mobilising people at the local level, because the community initiatives are recognisable and trusted, representing both a social and an economical value.

Understanding

In the following *Understanding phase,* the exploratory study results were further analysed, leading to a generic understanding of the growth path of prosumer communities: the *start-up phase,* the *emerging growth phase,* the *maturity phase*, and the *decline or revival phase*. Typical activities for the start-up phase are setting up a legal entity for the prosumer community and the elaboration of a first business plan. The emerging growth phase is

characterised by the activities of member recruitment, setting up working groups, the composition of a service portfolio including the organisation of sustainable energy supply, the organisation of collective energy projects and the participation in a smart grid pilot project. Many prosumer communities are in the emerging growth phase. The maturity phase is reached when the number of members is hardly growing anymore, various sustainable energy projects have been realized and smart grid technologies and smart energy services are integrated in the daily operations of the local energy provision system. The decline or revival phase, where the organisation of the community enters a period of decline or transition, is not yet relevant and thus not addressed within our research.
The Understanding phase of our research was concluded by formulating requirements for enhancing decisions of prosumer communities along their growth path.

Design

Next, in the *Design phase*, we presented the artefact that meets the formulated requirements. That is, we provide the *prosumer community shopping mall* as a metaphor reflecting an integrated, full-service environment. The shopping mall is an online portal, which can be used by prosumer communities and their members (i.e. the customers) to find and select in the various shops information, tools, and services that they need in a specific stage of their development process. For example, a hand book or documents from other prosumer communities that can be used as example or inspiration for starting up an initiative; or a service for monitoring the operation of a collectively owned wind mill; or a demand response service for switching on/off household appliances based on the momentary availability of sustainable energy. The information, tools, and services that are displayed in the shops in the shopping mall are developed by multiple service providers. The shopping mall facilitator, as the operator of the shopping mall, provides a set of generic services to the customers and generic services to the service providers. The service providers can use generic services to construct new services and deploy them in one or more of the shops. The customers use generic services to guide them through the shopping mall in their search for information, tools and services that they need. Some of the generic services being offered are: directory services, profile management services, recommendation services, personalisation services, one-stop-shopping and settlement services, and service construction and deployment services.
The shopping mall was instantiated in a prototype. With this prototype the generic services and the extensive service offering in the various shops of the prosumer community shopping mall could be visualised and demonstrated.

Evaluation

Finally, in the *Evaluation phase* of our research, group evaluation sessions were held with representatives from different prosumer communities (AmersVolt, Eemstroom and GrEK-Groninger Energie Koepel), next to individual sessions with eight energy experts. By means of a task assignment form, the respondents were guided step by step through the shopping mall prototype. At the end of the sessions the participants filled in a questionnaire to evaluate the perceived usefulness and usability of the shopping mall.

The evaluation results indicate that the respondents appreciate the shopping mall as being an attractive concept. They consider the prototype to be a valuable tool for getting insight in the basic principles of the shopping mall and which services and functionalities are being offered. As strong points of the shopping mall were brought forward 'the large collection of services in one place', which is 'continuously updated', while 'the shopping mall relieves prosumer communities'. The role of the shopping mall facilitator is seen as a major prerequisite. This actor should be independent, trustful, and transparent. The given usability feedback is valuable for a future implementation of the shopping mall. The evaluation results further indicate that the shopping mall is specifically useful for:

- Starting-up a prosumer community, because the shopping mall provides relevant information and examples, which cannot be found elsewhere.
- The emerging growth phase, because it provides support and relevant services for realising local energy supply and for setting-up a local energy project, which cannot be found elsewhere.
- The maturity phase, because it provides services that are useful for the daily operation of a prosumer community.
- Individual community participants, because it provides useful services for home energy management.

The objective of our research was to contribute to the growth and development of prosumer communities by providing a solution that would enhance their decisions as they encounter barriers and complexities along the road ahead. To conclude, the evaluation reveals that the prosumer community shopping mall is perceived as a useful and usable artefact for enhancing decisions along the growth path.

Nederlandse samenvatting

Het transitieproces naar een duurzame samenleving heeft de afgelopen tien jaar een opmerkelijke groei laten zien van het aantal lokale energie communities. Deze, door burgers geïnitieerde, collectieve initiatieven streven er naar om op lokaal niveau een zelfvoorzienende, duurzame energievoorziening te realiseren. Deze initiatieven worden ook wel *prosumer communities* genoemd. Als randvoorwaarde voor succes van deze prosumer communities geldt dat een combinatie van ondernemerschap en kennis van de energiemarkt en energie technologie onontbeerlijk is. Daarom moeten prosumer communities gefaciliteerd worden om ze te ondersteunen in het nemen van beslissingen als het gaat om de noodzakelijke kennis- en expertbronnen. Een geïntegreerd concept, dat het volledige spectrum van besluitvorming gedurende het groeipad van prosumer communities beslaat, is tot op heden niet beschikbaar.

Dit onderzoek richt zich op hoe prosumer communities kunnen worden gefaciliteerd tijdens hun groeipad, van eerste idee en oprichting van een lokale organisatie tot en met het bereiken van een volwassen, zelfvoorzienende lokale energie community. Om een passende versterking van de besluitvorming voor prosumer communities te ontwikkelen, hebben we de design science filosofie van Hevner als uitgangspunt gekozen, en hebben we de inductive-hypothetic onderzoeksstrategie van Sol gevolgd, die bestaat uit vier verschillende fasen: *Exploratie, Begrip, Ontwerp* en *Evaluatie.*

Voorafgaand aan de exploratiefase is er een literatuuronderzoek uitgevoerd om een lens te creëren waardoor vanuit drie verschillende perspectieven naar het fenomeen van de opkomende prosumer communities wordt gekeken:

- Wat is de motivatie van mensen om een prosumer community op te starten of om zich aan te sluiten bij een initiatief?
- Hoe zijn de initiatieven georganiseerd en in welke contextuele omgeving opereren ze?
- Welke technologische ontwikkelingen zijn van toepassing op prosumer communities?

Exploratie

Het doel van de *Exploratiefase* is om een beter beeld en dieper inzicht te verkrijgen in de ontwikkeling van prosumer communities. Daarvoor is een exploratie-onderzoek uitgevoerd bestaande uit case studies van prosumer

communities, groepssessies met individuele prosumer community deelnemers en interviews met diverse belanghebbenden uit het waardennetwerk van prosumer communities.

De geselecteerde prosumer communities voor de case studies TexelEnergie, Grunneger Power, LochemEnergie en Zeenergie zijn allen door burgers opgezet en waren al meer dan twee jaren actief. Deze prosumer communities hebben gekozen voor de juridische entiteit van coöperatie met uitgesloten aansprakelijkheid. De case studies hebben ons inzicht verschaft in de geschiedenis van de prosumer communities, hun doelen en organisatievorm, welke activiteiten ze tot nu toe hebben uitgevoerd (o.a. collectieve inkoop van zonnepanelen, organisatie van duurzame energielevering, het geven van energieadvies, etc.), en welke slimme energiediensten zijn uitgerold in de smart grid pilot projecten waarin ze participeerden. Verder hebben we achterhaald welke activiteiten ze voor de toekomst gepland hebben. Nadrukkelijk kwam het belang naar voren van hun lokale aanwezigheid en het hebben van een lokale identiteit, waarmee mensen zich kunnen identificeren. Daarnaast werd naar voren gebracht dat het nastreven van duurzaamheidsdoelstellingen, in combinatie met het stimuleren van de sociale cohesie en lokale werkgelegenheid, worden beschouwd als belangrijke drivers voor de prosumer communities.
Uit de groepssessies met individuele prosumer community deelnemers kwam naar voren dat de meerderheid van de deelnemers werd gedreven door zowel duurzaamheids- als economische motieven. Vertrouwen, controle en bruikbaarheid werden genoemd als belangrijke aspecten bij het gebruik van geautomatiseerde gereedschappen voor energiebeheer in een smart grid omgeving. Verder gaven deelnemers aan graag inzicht te willen verkrijgen in hun energieverbruik en feedback te willen ontvangen op hun energiegedrag.
De geïnterviewden uit het waardennetwerk van prosumer communities vertegenwoordigden verschillende partijen waaronder netwerkbeheerders, energieleveranciers, de overheid, onderzoeks- en consultancy bedrijven en dienstenleveranciers. De geïnterviewden werd gevraagd hun visie te geven op de toekomstige ontwikkelingen in de energiesector, en in het bijzonder welke rol zij daarin zagen weggelegd voor prosumer communities. Tijdens de interviews is een breed scala aan onderwerpen de revue gepasseerd. Zo werden onder anderen de resultaten van de case studies door de respondenten bevestigd, waarbij ze de problemen die prosumer communities ondervinden herkenden. Daarnaast werd aangegeven dat de rol van de prosumer communities als cruciaal wordt gezien om lokaal mensen te mobiliseren, omdat de community initiatieven herkenbaar zijn en vertrouwd worden, en een sociale en economische waarde vertegenwoordigen.

Begrip

In de daaropvolgende *Begripsfase* zijn de resultaten van de exploratieve studie verder geanalyseerd, wat heeft geleid tot een generiek begrip van het groeipad van prosumer communities: *de opstartfase, de opkomende groeifase, de volwassenheidsfase* en *de vernieuwingsfase*. Typerende activiteiten voor de opstartfase zijn het opzetten van een juridische entiteit voor de prosumer community en het uitwerken van een eerste business plan. De opkomende groeifase wordt gekarakteriseerd door activiteiten zoals ledenwerving, het opzetten van werkgroepen, het samenstellen van een dienstenportfolio waaronder het organiseren van duurzame energielevering, het organiseren van lokale energieprojecten en het deelnemen aan een smart grid pilot project. Veel van de prosumer communities zitten nog in de opkomende groeifase. De volwassenheidsfase wordt bereikt wanneer het aantal leden niet of nauwelijks meer groeit, er al verschillende energieprojecten zijn gerealiseerd, en smart grid technologieën en slimme energiediensten verregaand zijn geïntegreerd in de dagelijkse gang van zaken in het lokale energievoorzieningensysteem. De vernieuwingsfase, waarbij de community organisatie een periode van achteruitgang en transitie doormaakt, is nu nog niet relevant en is daarom ook niet meegenomen in ons onderzoek. De begripsfase van ons onderzoek is afgesloten met het formuleren van een aantal voorwaarden voor het versterken van besluitvorming voor prosumer communities gedurende hun groeipad.

Ontwerp

In de *Ontwerpfase* is het artefact gepresenteerd dat voldoet aan de geformuleerde voorwaarden. We gebruiken *de prosumer community shopping mall* als metafoor voor een geïntegreerde, volledig verzorgde dienstenomgeving. De shopping mall is een online portaal, die door prosumer communities en hun leden kan worden gebruikt (de klanten) om in de verschillende winkels informatie, gereedschappen en diensten te vinden en te selecteren, die ze nodig hebben in een specifieke levensfase van hun ontwikkelingsproces. Denk daarbij bijvoorbeeld aan een handboek of documenten van andere prosumer communities die als voorbeeld of inspiratiebron kunnen worden gebruikt voor het opstarten van een initiatief; of een dienst voor het op afstand operationeel beheren van een gemeenschappelijke windmolen; of een demand respons dienst die op afstand huishoudelijke apparaten kan aan-of uitzetten op basis van de tijdelijk beschikbare duurzame energie. De informatie, gereedschappen en diensten die zijn te vinden in de verschillende winkels in de shopping mall, zijn door meerdere dienstaanbieders ontwikkeld. De shopping mall facilitator, als beheerder van de shopping mall, biedt een verzameling generieke diensten voor klanten, alsook generieke diensten voor dienstaanbieders. De

dienstaanbieders kunnen de generieke diensten gebruiken om nieuwe diensten te construeren en ze vervolgens uit te rollen in een of meerdere winkels in de shopping mall. De klanten gebruiken de generieke diensten om zich te laten begeleiden door de shopping mall in hun zoektocht naar informatie, gereedschappen en diensten die ze nodig hebben. Enkele van de generieke diensten die worden aangeboden zijn: gidsdiensten, profielbeheer diensten, aanbevelingsdiensten, personalisatiediensten, one-stop-shopping en verrekeningsdiensten, en constructie en uitroldiensten.
De shopping mall is geïnstantieerd in de vorm van een prototype. Met dit prototype kunnen de generieke diensten en het uitgebreide dienstenaanbod in de verschillende winkels in de shopping mall worden gevisualiseerd en gedemonstreerd.

Evaluatie

Als afronding van ons onderzoek zijn in de *Evaluatiefase* groepsevaluatiesessies gehouden met vertegenwoordigers van verschillende prosumer communities (AmersVolt, Eemstroom en GrEK-Groninger Energie Koepel), naast individuele sessies met acht energie experts. Aan de hand van een takenformulier zijn de respondenten stapsgewijs door het shopping mall prototype heengeleid. Aan het eind van de sessies vulden de deelnemers een vragenlijst in om de ervaren bruikbaarheid en gebruiksvriendelijkheid te evalueren.

De evaluatieresultaten geven aan dat de respondenten de shopping mall waarderen als een aantrekkelijk concept. Ze zien het prototype als een waardevol instrument om inzicht te krijgen in de basisprincipes van de shopping mall en welke diensten en functionaliteiten daarin worden aangeboden. Als sterke punten van de shopping mall werden genoemd ‘de grote verzameling diensten op één plaats’, die ‘continu worden vernieuwd’, terwijl ‘de shopping mall de prosumer communities ontzorgt’. De rol van de shopping mall facilitator wordt als een belangrijke randvoorwaarde bestempeld. Deze speler moet onafhankelijk, betrouwbaar en transparant zijn. De feedback die is gegeven met betrekking tot de gebruiksvriendelijkheid is waardevol voor een toekomstige implementatie van de shopping mall.

De evaluatieresultaten geven verder aan dat de shopping mall specifiek bruikbaar is voor:

- Het opstarten van een prosumer community, omdat de shopping mall relevante informatie en voorbeelden aanbiedt, die niet ergens anders kunnen worden gevonden.
- De opkomende groeifase, omdat ondersteuning en relevante diensten worden aangeboden voor het realiseren van lokale energielevering en het opzetten van lokale energie projecten, hetgeen niet elders kan worden gevonden.
- De volwassenheidsfase, omdat diensten worden aangeboden die bruikbaar zijn voor de dagelijkse operationele uitvoering van een prosumer community.
- Individuele community deelnemers, omdat bruikbare diensten worden aangeboden voor home energy management.

Het doel van ons onderzoek was om een bijdrage te leveren aan de groei en ontwikkeling van prosumer communities, door een oplossing te bieden die de besluitvorming zou versterken wanneer ze tegen barrières en complexe problemen aanlopen op hun weg voorwaarts. Concluderend kunnen we stellen dat de evaluatie aangeeft dat de prosumer community shopping mall als een bruikbaar en gebruiksvriendelijk artefact wordt ervaren voor het versterken van de besluitvorming gedurende het groeipad.

Curriculum Vitae

Wim Timmerman was born on 16th June 1962 in Ruinerwold, the Netherlands. He attended secondary school at the Menso Alting College in Hoogeveen from 1974 to 1981. From 1983 to 1990 he studied Computer Sciences at the University of Twente, where he did his internship partly on the University of Waterloo, Canada and at the Ice Centre Canada in Ottawa. He graduated at the University of Twente on the subject of graphical user interface design for a multi-processor operating system.

After his studies he had a career in the research department of two companies, KPN and TNO. New service development in the telecommunications domain is the main red line that characterises his work.

In 2004 he joined the Hanze University of Applied Sciences, where he started working as project leader of the Competence Centre Human Technology. In 2006 he became a lecturer at the department of Human Technology and Industrial Product Design, focusing on usability research and sustainability, next to his tasks as study coach, project coach, and supervisor of graduation students. In 2007 he started his part time PhD research at the Centre of Applied Research and Innovation – Energy. This gave him the opportunity to broaden and deepen his knowledge in the field of renewable energy and sustainability, specifically in the area of local energy communities, which has his strong personal interest. He integrated the subject of sustainability in several project assignments in the educational program of Human Technology and Industrial Product Design. He also participates in the development and implementation of two energy related master programmes at the Hanze University of Applied Sciences.